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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

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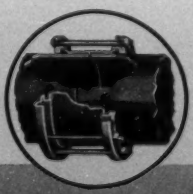

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New England Water Works Association
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WATER SUPPLY IN WAR TIME

BY JOHN BOWMAN*

[*Read November 25, 1941.*]

In the paper submitted on "British Waterworks Practice" to your Association in 1939, the writer made the following comment: "It has been gradually forced upon us that not only must we be prepared to meet possible aggression on the Continent of Europe but also attacks on our own cities from the air". These words were written long before the war broke out. Since then attacks from the air on cities in Great Britain have taken place giving rise to problems.

The water supply to any community, in normal times, is primarily for domestic and commercial purposes. It is of secondary importance in providing water for fire extinguishing purposes. In war time, the provision of water for fire extinguishing purposes becomes of increasing importance. The ideas of water engineers, therefore, have had to be considerably altered in view of the problems which war time presents. Some towns in Great Britain have systems of piping entirely inadequate for fire fighting purposes for even normal circumstances. Some years ago, the writer presented to the Institution of Fire Engineers a paper dealing with this subject in which it was pointed out that in a few towns the piping had not been laid down sufficiently large to deal with even ordinary fires. For some years, the matter had been under consideration by fire authorities, but nothing had been done in many towns, although, in Edinburgh and several other large towns, this problem was recognized, and larger piping was gradually replacing older piping to provide water for fire fighting, as well as for domestic and commercial supplies.

In the event of damage to a main, it is desirable to shut off as short a section of the damaged main as possible so that adjoining streets may not be affected. For this reason, it is desirable that all streets

*City Water Engineer, Edinburgh, Scotland, and Past President of the Institution of Water Engineers, Great Britain.

should be interconnected and that long streets should be divided into sections by the placing of intermediate valves.

All valves should be overhauled to see that they are in proper working order. The surface boxes over the valves should be distinguished so that they can be readily found in emergency. This has been done in Edinburgh and other towns by painting round the surface box on the valve. In Edinburgh, this paint is renewed regularly, and the surface boxes over the valves are greased at the same time so that they can be readily opened. Additional valve keys have been provided so that at no point is there a valve which is further away than a few minutes' walk from a valve key. These valve keys are chained or locked at points known to the water officers who would operate the valves.

In ordinary circumstances, a few men only are necessary for operating valves, but in war time it may be necessary to have a great many more men available. Each man is given a small area where he would have charge of all the valves. Immediately the sirens sound indicating the approach of enemy aircraft, the man proceeds at once to the post to which he has been allocated, and his duty would be to close down the valves which would control a section of the pipe that had been broken. Alternatively, it might be necessary, if a crater had been formed, to allow the water to run into the crater so that this water could be used for pumping for fire purposes. This is a matter which would be left to the discretion of the officer operating the valves.

The ordinary staff of a water department may not be sufficient to deal with a number of incidents, and, to assist in this purpose, many towns have enrolled operative plumbers as auxiliary water officers to assist in operating valves. These plumbers are given certain streets in which they would operate, and they are instructed as to the valves to be operated. Generally speaking, damage to water mains occurs during the night, and all that could be done during the night is to shut off the section of the damaged main leaving the repairs of the main until daylight comes, because, apart from the fact that no lights are allowed during a blackout, it would not be possible to carry out repairs until a raid was over. This is a general outline of controlling the distribution system of an ordinary town.

In order to carry out repairs, stocks of pipes have been accumulated, and these are stored at various points. Experience has

shown that a town may not be able to carry out all the repairs with its own staff, and arrangements have been made that all towns shall come to the mutual assistance of one another. In the case of certain towns which have been heavily "blitzed", this arrangement has worked most satisfactorily. The Government Department of Health is at once on the scene to give assistance to the authority and, if necessary, to call in other authorities to assist. While comparatively few towns have suffered extensive damage involving many repairs, actually all towns are on the footing of, as far as possible, being ready to deal with any emergencies which may arise or to assist other authorities if called upon to do so.

One important point in re-charging a damaged main is that into the damaged main contamination may have been conveyed. For instance, a main pipe and a sewer may lie in the same street and be damaged at the same time. When such damage takes place, there is a danger of contamination through the contents of the sewer being washed into the water main. After a main is repaired and before it is put into use again for supplying water for domestic purposes, the pipe is charged with a solution of chloride of lime, and after this has been allowed time to be effective, the pipe is scoured out and then brought into operation. This is the general scheme in operation in most towns for the repair of damaged mains. It may be that a large area is damaged and repairs are delayed. Where this occurs, in order to maintain a supply of water to inhabitants, water tanks are set up in the streets from which supplies can be drawn or alternatively water carts are provided for distributing water. These, in general, are the outlines for the maintenance of the distribution system.

Where a distribution system is supplied through one source only and perhaps through one trunk main, any rupture of the trunk main would at once dislocate the supply to the whole area. A second line of piping to supply the area is desirable and in some cases this has been laid. Many of the larger areas in Great Britain have more than one supply pipe, and therefore the danger of complete dislocation of the water supply is less. It is desirable, where the trunk main is a long one, to have valves placed on it at more frequent intervals than is the usual practice, because to empty a long length of trunk main for repairs and re-charging takes a considerable time, whereas, if there

are shorter sections, the emptying and repair of the pipe and the recharging are reduced to a minimum.

Where water passes into a filtering station, the water is usually filtered and passed into service tanks from which the supply is drawn. It may be that in normal circumstances no arrangements have been made in large works for by-passing the water, that is to say, the water passes into the filter works and is taken through separate pipes from the service tank to the town or area supplied. It is desirable, where such arrangements do not exist, that a by-pass main should be laid to connect the inlet pipe with the outlet pipe from the works. This means the sending into the area of unfiltered water, and chlorinating plants should be installed so that all water passing into the area is chlorinated. In Great Britain, on the instruction of the Government, chlorinating plants have been installed in all water areas even where the water is filtered and these are in operation. The method of application generally is by means of chlorine gas, but, in emergency, a solution of chloride of lime may be applied to the water being sent in.

Where water is supplied from surface reservoirs, it has not been considered necessary, and it would indeed, be difficult to provide any protective works. Fortunately, it is considered that the destruction of the dam of an impounding reservoir would be extremely difficult. The only vital spot at the impounding works is the valve tower, and this presents such a small target that it would be only by chance that it might be damaged. The craters made by the larger bombs even on an earth embankment would not be such as to completely wreck the dam. Indeed, probably the ordinary bomb crater might be filled in and repaired within a comparatively short time.

In the case of pumping stations, a direct hit on a pumping station might easily put it out of action, and, where there is only one pumping station in an area, this would have serious results. In the larger areas, there are usually several pumping stations for various supplies. It is desirable that alternative pumping stations should be provided. Generally speaking, the driving power of the ordinary pumping plant is either by means of electricity or by generated steam. The alternative pumping plant should be independent of either of these sources—either oil or petrol driven.

These in general are the outlines for air raid precautions for the protection of a water supply. There is in addition the training of the

staff. Every member of a waterworks staff should be trained to carry out his duties in gas-proof clothing, and this has been done in Great Britain. Every member carries a gas mask and steel helmet. In addition to the preliminary training, it is necessary that all members of the staff should practice at regular intervals the wearing of the gas mask and helmet, and this is done, the men having practice twice a week for half an hour wearing the gas mask and helmet. In the event of men working in a gas-infected area, when they return from duty, they must pass through a decontamination station. The whole of the clothing that is worn is taken off at the first chamber, and the men pass through shower baths so as to remove any possible trace of gas.

The provision of water for fire purposes can be augmented in many cases by the utilization of streams on which dams may be constructed or small ponds. In larger areas, provision for open tanks should be made, but such tanks should not contain less than 150 to 200 thousand Imperial gallons, that is to say 180 to 240 thousand U. S. gallons. From these open tanks, fire engines may work for a considerable time, and, while they are at work, it might be possible to run lines of piping from undamaged mains into the tank from which the engines are working so as to maintain the water supply. Where there is a river or stream of any size, it may be possible to arrange intakes from which the water can be pumped into special lines of piping laid on the surface of the ground. On such piping, outlets may be provided to which the suction pipes of the fire engines may be attached. There would be a pumping engine placed at the sump on the river or stream, and this pumping engine would pump water into the delivery pipe.

In buildings, where sprinkler installations have been installed, supplied from the local authority's water system, an alternative supply may be sometimes obtained from a river or stream so that, in the event of the breakdown of the water system, water may be pumped from an independent source into the sprinkler system. The objection to this is that the water pumped into the system may be from an impure source and might be the means of contaminating the mains when the original method of supply is reverted to. Some engineers object to this system, but in Edinburgh we have permitted such schemes to be carried out. On all sprinkler systems, there is a reflux valve which, if tight, would prevent any water in the sprinkler system finding its way into the piping system. There is also a sluice valve

on such systems as well which would, in normal cases, be shut if the water were off the mains and pumping were being resorted to from another source.

These, in general, are the outlines for air raid precautions which have been found desirable in Great Britain. Generally speaking, the arrangements are such that, notwithstanding heavy damage in some cases, in large areas to water mains, a supply has been maintained forthwith and the restoration and repairs of works carried out in an extremely short time.

The writer had intended to visit America before the war broke out. Perhaps, when the war is ended, and perhaps this will be sooner than many people had hoped to expect, opportunities may be given for British engineers to visit America and to confer with their American colleagues on the greater problems of water supply which war time conditions have produced.

STATE EMERGENCY PLAN OF THE COMMONWEALTH OF MASSACHUSETTS

BY ARTHUR D. WESTON*

[*Read September 24, 1941.*]

Massachusetts is the third most densely populated state in the Union being exceeded in population per square mile of area only by New Jersey and Rhode Island. Massachusetts is an industrial state and as such has large and varied industries situated in the principal river valleys and along its coastal areas. To meet the needs of industry and its allied population, public water supplies have been generously introduced until, at present, 256 of the 351 cities and towns of the state have public water supplies and over 97% of the population of the state is contained in these cities and towns. These water supplies are owned by the municipalities, water or fire districts, or water companies. Many of these systems of water supply are to be found along interstate streams having comparatively large drainage areas and are subject to floods of considerable magnitude such as occurred in the years 1927, 1936 and 1938, while others are placed along the sea coast and vulnerable to damage such as resulted from the tidal wave that accompanied the hurricane of September 1938.

Because of the vulnerability of the densely populated areas to damage and loss of life and the difficulty in rendering aid, to such areas at times of disaster, the Office of the Adjutant General of the Executive Department of the Commonwealth, shortly after the floods of 1936, began the formulation of an emergency plan to be effective during such disasters. This plan, in the beginning, was limited almost entirely to the military forces but worked so successfully during the floods and tidal wave accompanying the hurricane of 1938 that it has now been expanded to include all state and allied agencies that might naturally be called upon to render aid during a major emergency. Through the careful planning of Brigadier General Edgar C. Erickson, the present Adjutant General, this plan has been expanded so as to

*Chief Engineer, Massachusetts Department of Public Health, Boston, Mass.

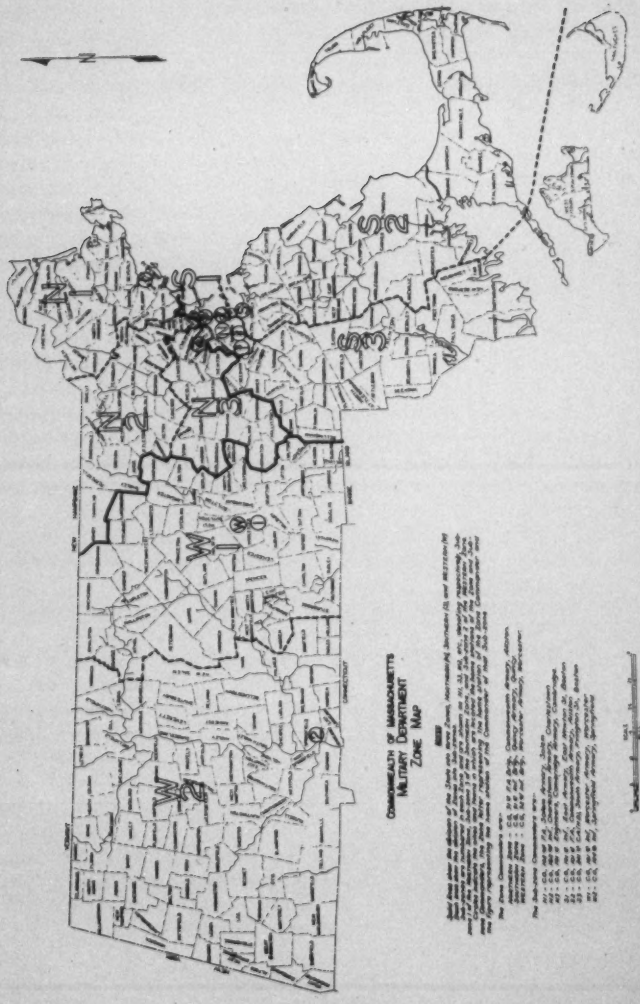

COMMONWEALTH OF MASSACHUSETTS
MILITARY DEPARTMENT
ZONE MAP

FIG. 1.

be effective not only at times of disasters from floods, hurricanes, fire, etc., but also for use in state and national defense. The purpose of this paper is to present the plan so far as it relates to public health and public water supplies of the state.

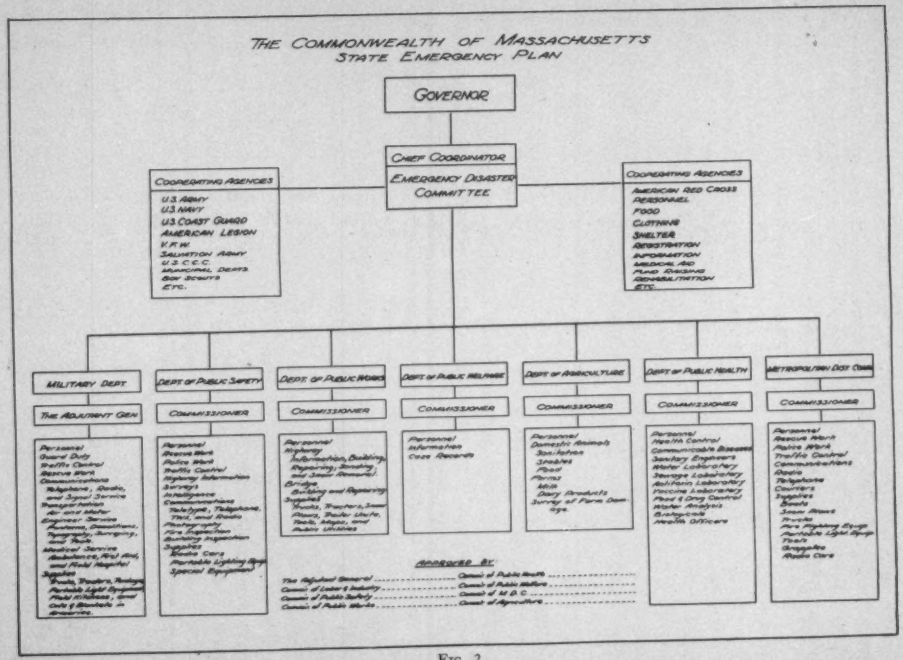
Under the Massachusetts State Emergency Plan, the state is divided into three major military zones, viz., the Northern or "N" Zone, the Southern or "S" Zone, and the Western or "W" Zone. These major zones are further divided into sub-zones. The "N" Zone has three sub-zones known as Sub-zones N-1, N-2, and N-3. Similarly the "S" Zone is divided into Sub-zones S-1, S-2, and S-3, and the "W" Zone is divided into two Sub-zones known as Sub-zones W-1 and W-2. These Zones and Sub-zones are shown in Fig. 1.

The organization developed for carrying out the plan is under the direction of His Excellency the Governor who under our state constitution is the Commander-in-Chief of the National Guard or State Guard as the case may be. His chief coördinator is the Adjutant General who in turn is assisted by an Emergency Disaster Committee on which the following state agencies are represented: Military Department, Department of Public Safety, Department of Public Works, Department of Public Welfare, Department of Agriculture, Department of Public Health, and Metropolitan District Commission.

The organization as developed also includes the following cooperative agencies: American Red Cross, U. S. Army, U. S. Navy, U. S. Coast Guard, American Legion, Veterans of Foreign Wars, Salvation Army, U. S. Civilian Conservation Corps, Municipal departments, Boy Scouts, Girl Scouts, etc.

A very important coöperative agency has been added more recently. This is the Governor's Committee on Public Safety which was appointed to build up an organization to operate effectively in defense against enemy attacks. It will operate similarly to the British organization which has been so effective in its ARP (Air Raid Precautions) work in England and Scotland. The work of the Committee on Public Safety works in close coöperation with the organization of the State Emergency Plan.

An organization chart of the State Emergency Plan is shown in Fig. 2. It will be seen from this chart that provision has been made for the various department heads and heads of coöperating agencies to be readily available at all times for immediate consultation and to


THE COMMONWEALTH OF MASSACHUSETTS
STATE EMERGENCY PLAN
GOVERNOR
CHIEF COORDINATOR
EMERGENCY DISASTER COMMITTEE
COOPERATING AGENCIES
U.S. ARMY
U.S. NAVY
U.S. COAST GUARD
AMERICAN LEGION
V.F.W.
SALVATION ARMY
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MUNICIPAL DEPTS.
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The Adjutant General
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Council of Public Welfare
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Council of Public Safety
Council of Agriculture
Council of Public Works

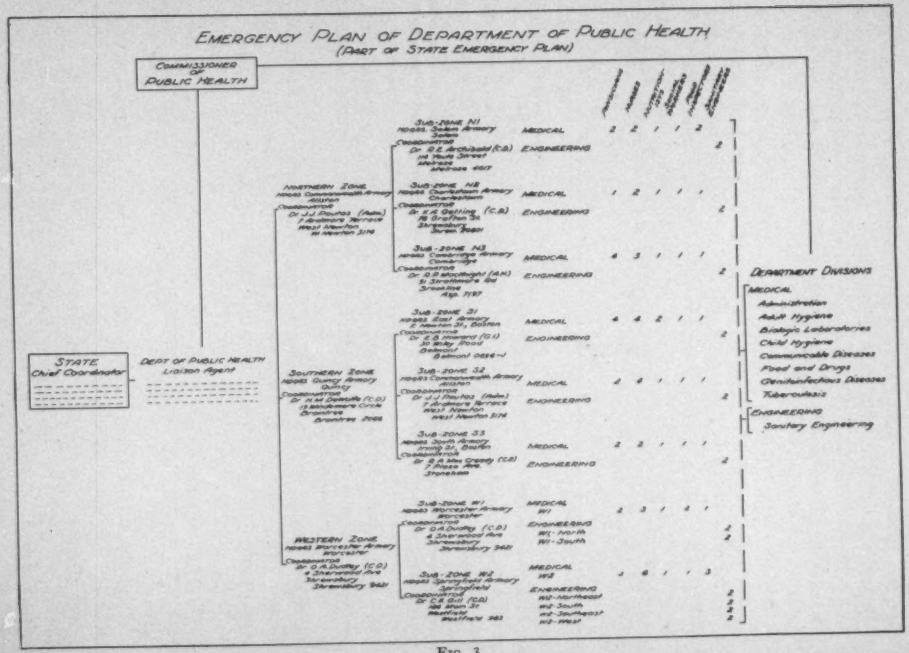
FIG. 2.

receive any necessary instructions. To complete this very important link in the organization, each state department has been requested to name a person to represent the department on the headquarters staff of the Adjutant General whenever a meeting of the staff may be called. These staff representatives are known as Technical Advisors and some have actually been commissioned to make their work more effective. The author is one of those so commissioned to plan and advise in matters relating to public health in general and particularly to public water supplies. In carrying out this assignment, there have been developed two sub-plans as a part of the State Emergency Plan, one that relates to public health in general and one that relates only to matters of public water supply.

The organization under the plan relating to public health, is headed by the Commissioner of Public Health and provides in each of the Military Zones and Sub-Zones a working body of Health Administrators, Health Officers, Sanitary Engineers, Laboratory Workers, Nurses and others, thus making available the facilities of the Department of Public Health in all its branches to any community as the needs may arise. This organization is set forth in Figs. 3 to 5.

A comparison of these charts with the map (Fig. 1) outlining the military zones of the state will show that the working organization of the Department of Public Health is so spread that personnel will be available in any part of the state at times of disaster without dependence upon moving such personnel from headquarters at the State House which was so difficult during the floods and hurricane periods of 1938. To guard further against this difficulty and in order to make available additional laboratory and engineering services at times of emergency, the department plans to call upon certain laboratories located throughout the state for emergency service and upon private agencies for any additional engineering services that may be required.

It has been found to be impracticable to make an inventory of those laboratory and additional engineering services because of the changing demands on private laboratories and engineering offices. However, it is felt that a sufficient number of these auxiliary services have been listed to afford the additional assistance required in an emergency. It was practicable to make an inventory of the state and municipal facilities, and, as a result, the part of the Department of


EMERGENCY PLAN OF DEPARTMENT OF PUBLIC HEALTH
(PART OF STATE EMERGENCY PLAN)
COMMISSIONER OF PUBLIC HEALTH
STATE
Chief Coordinator
DEPT OF PUBLIC HEALTH
Liaison Agent
NORTHERN ZONE
SOUTHERN ZONE
WESTERN ZONE
Sub-Zone N1
Sub-Zone N2
Sub-Zone N3
Sub-Zone S1
Sub-Zone S2
Sub-Zone S3
Sub-Zone W1
Sub-Zone W2
MEDICAL
ENGINEERING
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MEDICAL
Administration
Adult Hygiene
Biologic Laboratories
Child Hygiene
Communicable Diseases
Food and Drugs
Geninfectious Diseases
Tuberculosis
ENGINEERING
Sanitary Engineering

FIG. 3.

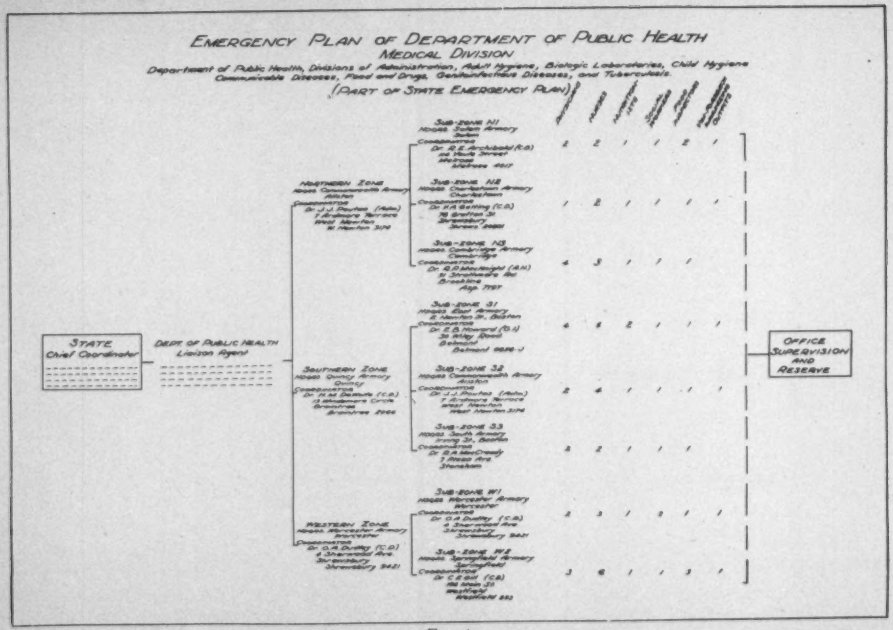

EMERGENCY PLAN OF DEPARTMENT OF PUBLIC HEALTH
MEDICAL DIVISION
Department of Public Health, Divisions of Administration, Adult Hygiene, Biologic Laboratories, Child Hygiene
Communicable Diseases, Food and Drugs, Sanitation, Venereal Diseases, and Tuberculosis.
(PART OF STATE EMERGENCY PLAN)
STATE
Chief Coordinator
DEPT OF PUBLIC HEALTH
Liaison Agent
NORTHERN ZONE
SOUTHERN ZONE
WESTERN ZONE
SUB-ZONE N1
SUB-ZONE N2
SUB-ZONE N3
SUB-ZONE S1
SUB-ZONE S2
SUB-ZONE S3
SUB-ZONE W1
SUB-ZONE W2
OFFICE SUPERVISION AND RESERVE

FIG. 4.

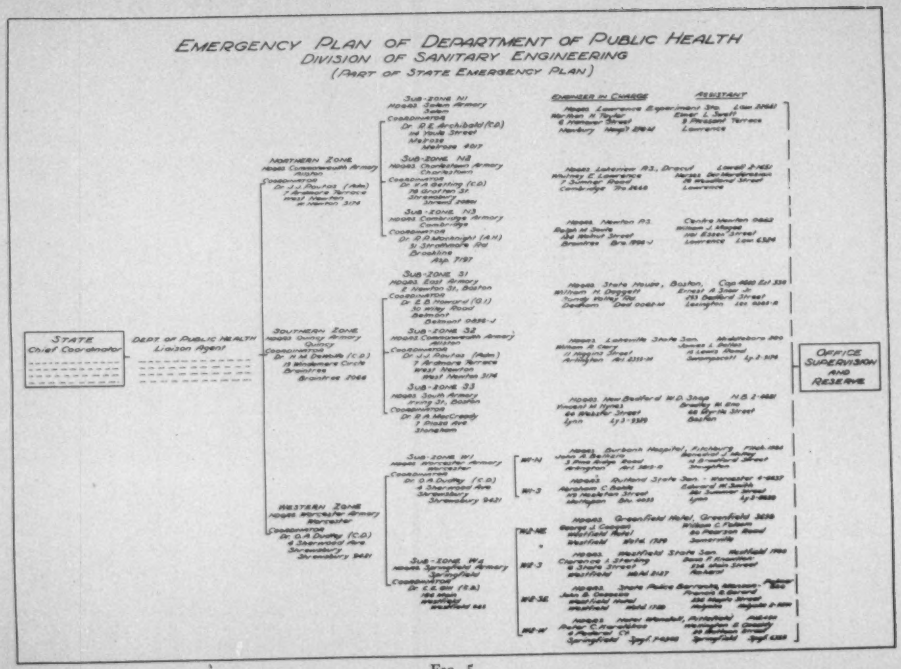

EMERGENCY PLAN OF DEPARTMENT OF PUBLIC HEALTH
DIVISION OF SANITARY ENGINEERING
(PART OF STATE EMERGENCY PLAN)
STATE
Chief Coordinator
DEPT OF PUBLIC HEALTH
Liaison Agent
NORTHERN ZONE
SOUTHERN ZONE
WESTERN ZONE
OFFICE
SUPERVISION
AND
RESERVE
ENGINEER IN CHARGE
ASSISTANT

FIG. 5.

Public Health in the State Emergency plan includes the names of all departmental personnel with addresses and telephone numbers, lists of all chlorinating or other equipment that may be useful and also lists of nearby commercial houses that can be expected to contribute further to such equipment. These inventories, of course, have to be revised from time to time. Sample Schedules 1 to 3 are indicative of the kind of data tabulated under the general public health plan.

SAMPLE SCHEDULE 1—PERSONNEL, LABORATORY FACILITIES, AND EQUIPMENT FOR SUB-ZONE N-1

Headquarters: Lawrence Experiment Station, Tel. Lawrence 22041.
Engineer in Charge: Worthen H. Taylor; Home—6 Hanover Street, Newbury; Tel. Newburyport 276-M.
Assistant: Elmer L. Swett; Home—9 Pleasant Terrace, Lawrence.
LABORATORY FACILITIES
Lawrence Experiment Station; Newburyport Shellfish Treatment Plant; Lawrence Water Treatment Plant; Salem and Beverly Water Treatment Plant.
EQUIPMENT
1–W. & T. Portable Chlorinator
(Manchester Water Department Unit) emergency
1–Hypo Chlorinator
5–Cans High-Test Chlorine
Note: Equipment Exchangeable with Sub-zone N-2
Zone Water Supply Coördinators:
Roger W. Esty, Superintendent, Danvers Water and Sewer Board; Office Tel.—Danvers 438; Home—55 Lindall St., Tel. Danvers 192.
Assistant Zone Water Supply Coördinator:
William B. Duffy, Superintendent, North Andover Public Works; Office Tel.—Lawrence 7964; Home—76 Greene St., North Andover, Tel. Lawrence 4867.

SAMPLE SCHEDULE 2—OFFICE SUPERVISION AND RESERVE EQUIPMENT

Room 203 (State House)
1–W. & T. Portable Chlorinator
No. G-54 (Assigned to Sub-zone N-2)
4–Cylinders Chlorine Gas (Small)
4–Cases (12 cans each) H. T. H.
1–Chlor-O-Feeder (Electric)
(Assigned to Sub-zone N-1)
2–Pair Wading Pants
Room 511A
1–Manometer Assembly (W. & T.)
3–Pair Rubber Boots

2–Raincoats
1–Hat
5–Chlorine Comparators
Chlorinators Available to Boston Office
1–W. & T. Portable Chlorinator, Newton Water Department.
Call Mr. Mark Croker, Cen. Newton 0882
(Assigned to Sub-zone N-3)
1–W. & T. Portable Chlorinator, Manchester Water Department.
Call Mr. H. B. Collins, Manchester 62-W
(Assigned to Sub-zone N-1)
1–W. & T. Portable Chlorinator, Gloucester Water Department.
Call Mr. Lester Hull, Gloucester 150
1–Chlor-O-Feeder (110-Volt D.C.), Lakeville State Sanatorium, Tel. Middleboro 280
1–Chlor-O-Feeder, Winchendon Water Department, Tel. 38
1–Chlor-O-Feeder, Walter E. Fernald School, Templeton Colony, Tel. Baldwinsville 6-2
Wallace & Tiernan Co., Inc., 350 Newbury Street, Boston, Tel. Kenmore 2686
Portable Chlorinators
Hypochlorinators (Electric Operated)

SAMPLE SCHEDULE 3—SUPPLY DEPOTS

Pumps:
Ingersoll-Rand Co., 285 Columbus Avenue, Boston, Tel. Kenmore 5635
Chicago Pump Co., 10 High Street, Boston, Tel. Hancock 7924
Duro Pump Co. of Boston, Inc., 274 Franklin Street, Boston, Tel. Hubbard 5580
The Equipment Co., 30 Prentiss Street, Boston, Tel. Highlands 2100
Gardner-Denver Co., 292 Main Street, Cambridge, Tel. Kirkland 6847
Gleason Gilbert Howe & Co., 28 St. Botolph Street, Boston, Kenmore 4593
Goulds Pumps, Inc., 210 South Street, Boston, Tel. Hancock 0480
Ralph P. Hall, Inc., 141 Milk Street, Boston, Tel. Hancock 4570
Hayes Pump & Machinery Co., 125 Purchase Street, Boston, Tel. Hancock 7957
Layne-Bowler N. E. Co., Inc., 1136 Statler Bldg., Boston, Tel. Liberty 5795
Perrin Seamans & Co., Inc., 606 Atlantic Street, Boston, Tel. Hancock 0909
Uniflow Manufacturing Co., 470 Boylston Street, Boston, Tel. Kenmore 0277

As has been stated previously, it was found necessary in the case of our public water supplies to establish an organization under the Adjutant General separate from the general public health plan. The magnitude of any worthwhile water supply organization made such an arrangement necessary. Accordingly, coördination of water-supply operation and water-supply equipment and supplies has been delegated

to the author as a member of the State Staff with the assistance of Francis H. Kingsbury, Associate Sanitary Engineer, and Joseph C. Knox, Assistant Sanitary Engineer of the Department of Public Health. In accordance with this plan of coördination, there have been assigned to the various military zones certain water supply coördinators whose duty it is to plan for and have charge of all emergency water-supply work in their respective zones. In addition, there have been appointed in the sub-zones certain assistants to these coördinators. These appointments and distribution of their assignments are as follows:

ZONE AND ASSISTANT ZONE WATER SUPPLY COÖRDINATORS

NORTHERN ZONE

Zone Water Supply Coördinator:

Roger W. Esty, Superintendent, Danvers Water & Sewer Board, Danvers, Mass.

Assistant Zone Water Supply Coördinators:

William B. Duffy, Superintendent, North Andover Public Works, North Andover, Mass.

James H. Reynolds, Assistant Superintendent, Lowell Water Works, Lowell, Mass.

Mark F. Croker, Superintendent of Distribution, Newton Water Works, Newton, Mass.

SOUTHERN ZONE

Zone Water Supply Coördinator:

Daniel M. Sullivan, Division Engineer, Water Division, Public Works Department, Boston, Mass.

Assistant Zone Water Supply Coördinators:

George A. Griffin, Engineer, Woods Hole, Mass.

Daniel W. Ryan, Superintendent, Brockton Water Department, Brockton, Mass.

H. C. Mandell, Superintendent, Water Department, New Bedford, Mass.

WESTERN ZONE W-1

Zone Water Supply Coördinator:

Leon A. Goodale, Superintendent, Bureau of Water, Worcester, Mass.

Assistant Zone Water Supply Coördinators:

Thomas E. Kennedy, Superintendent & Registrar, Water Division, Public Works Department, Fitchburg, Mass.

Samuel G. Wylie, Superintendent, Water Department, Webster, Mass.

WESTERN ZONE W-2

Zone Water Supply Coördinator:

Leland G. Carleton, Superintendent, Municipal Water Works, Springfield, Mass.

Assistant Zone Water Supply Coördinators:

Harold L. Field, Superintendent, Greenfield Water Department, Town Hall, Greenfield, Mass.

Patrick J. Lucey, Engineer, Holyoke Water Department, Holyoke, Mass.

Leon H. Reed, Commissioner, Department of Public Works, Pittsfied, Mass.

The work of these coördinators does not include any of the functions of the Metropolitan Water District and accordingly as the works of this district extend over nearly one half of the length of the state, the Metropolitan Water Supply Coördinators have been appointed as follows:

Metropolitan Water Supply Coördinator:

Samuel E. Killam, Director & Chief Engineer, Water Division, Metropolitan District Commission, Boston, Mass.

Assistant Metropolitan Water Supply Coördinators:

Harold J. Toole, Superintendent, Metropolitan Water Works, Clinton, Mass.

Allan Grieve, Jr., Assistant Superintendent, Metropolitan Water Works, Medford, Mass.

Albert J. LePage, Senior Engineering Aid, Metropolitan Water Works, Framingham, Mass.

Roy E. Kimball, Belchertown, Mass.

To complete the program, coördinators have been appointed to plan for the emergency distribution of water works equipment and chemicals and apparatus used in water treatment. The activities of

these coördinators will be state wide directly through the author on the state staff. These coördinators are as follows:

Water Supply Coördinator for Manufacturers:
Herbert W. Jacobs, 429 Lexington Avenue, Waltham, Mass.

Coördinator of Supply of Water Treatment Chemicals:
Frederick S. Gibbs, 350 Newbury Street, Boston, Mass.

Certain work was started early in the plan to get together for distribution to the coördinators, maps showing the locations of water mains 6 in. in diameter and larger, the locations and capacities of standpipes and reservoirs, and data relative to existing intermunicipal water works connections. The various coördinators have been instructed to bring this material up to date, to make inventories of their water works equipment, and, in the case of intermunicipal connections, to make sketches showing existing connections and possible future connections. They also have been instructed to ascertain the capacities of the principal water-supply mains and sources to feed the distributing systems. Figure 6 and Forms 1 to 5 typify the arrangement of data secured and to be secured.

After the plan herein indicated was laid out, a meeting was held at which the chief water supply coördinators, engineers of the Department of Public Health and the author were present. At this meeting, all present were acquainted by the Adjutant General and his Chief Intelligence Officer with the plan in all its phases and the need in case of an emergency of a working organization properly and smoothly coördinated. Later a meeting of all coördinators was held, and they were similarly informed and were supplied with appropriate identification cards which when equipped with photos, fingerprints and signatures were later stamped with the state seal. They thereby became officially members of the state staff of the Adjutant General operating in a civilian capacity. These various coördinators have been requested to advise water works officials as to the need for careful examination of the loyalty of all employees of their departments and as to the value of and necessity for municipal coöperation, the need of becoming acquainted with those parts of their water works system vulnerable to sabotage, and precautions against advertising any information that may be useful to subversive agents. The enthusiasm and coöperation

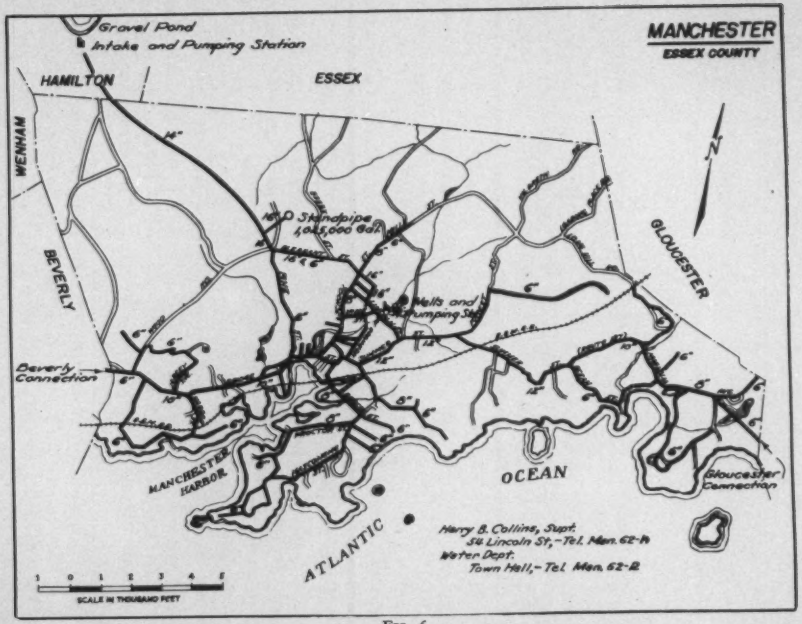

MANCHESTER
ESSEX COUNTY
Gravel Pond
Intake and Pumping Station
HAMILTON
ESSEX
WENHAM
BEVERLY
GLOUCESTER
N
Beverly Connection
Wells and Pumping Station
MANCHESTER HARBOR
OCEAN
ATLANTIC
Gloucester Connection
Harry B. Collins, Supt.
54 Lincoln St, - Tel. Man. 62-R
Water Dept.
Town Hall, - Tel. Man. 62-2
SCALE IN THOUSAND FEET

FIG. 6.

Form 1—Pumping Equipment

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ADJUTANT GENERAL
STATE EMERGENCY PLAN

Sub-zone.....

(*a*)

D Pumping Equipment (Pumping Engines)

Municipality	Type	Serial Number	Speed R.P.M.	Size Pulley	Size of Clutch Connection

Form 2—Intermunicipal Water Supply Connection

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ADJUTANT GENERAL
STATE EMERGENCY PLAN

Sub-zone .....

Municipality.....

C Possible water supply connection to adjacent municipalities
Direct water main connection

Name of Municipality	*Name of Municipality*
Size of Main	Size of Main
Pressure lb. sq. inch	Pressure lb. sq. inch
Name of Street	Name of Street

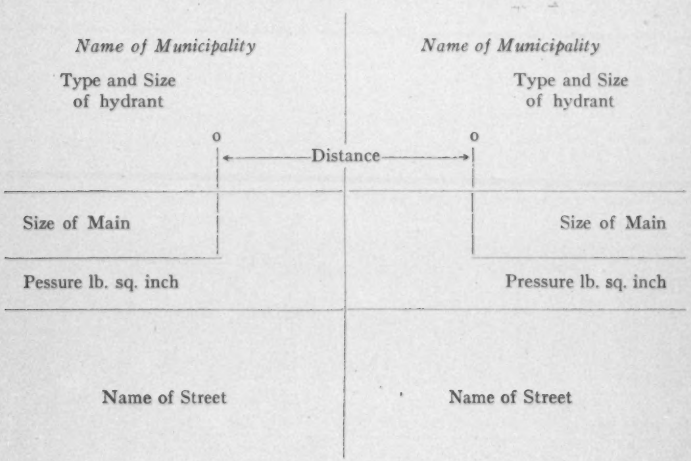
Form 3—Possible Intermunicipal Water Supply Connection

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ADJUTANT GENERAL
STATE EMERGENCY PLAN

Sub-zone .....

Municipality .....

C Possible water supply connection to adjacent municipalities
Hydrant connection



Form 4—Inventory of Pipe

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ADJUTANT GENERAL
STATE EMERGENCY PLAN

Sub-zone.....

E Inventory of Stock on Hand

NAME OF MUNICIPALITY OR COMPANY——————————.

DATE OF INVENTORY.....

.....PIPE

(Fill in material: Cent. C.I., Pit C.I., Transite, Century, Steel)

Use separate sheet for each kind of pipe INDICATE LINING AND COATING

to date of the water works coördinators and local water works officials have been most gratifying and can best be illustrated by the results of a local meeting of water works officials called for the purpose by the coördinator of one of the military zones, at which 19 municipalities were represented out of a possible 27. This is the type of coöperation we expected in the state of Massachusetts, and it can be credited largely to the spirit of coöperation built up over a number of years by the New England Water Works Association.

Our difficulties, thus far, have been minor ones, but one of them

Form 5—Well Drivers and Equipment

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ADJUTANT GENERAL
STATE EMERGENCY PLAN

DATE.....

Well Drivers and Equipment

DRIVEN WELLS

Concern	Rigs in Stock	2½-in. Drive Pipe in Stock	Points in Stock	Test Pumps in Stock	
				Centrifugal	Diaphragm

CABLE TOOL WELLS

Concern	Rigs in Stock	Size and Depth of Drilled Hole	Length and Size of Casings in Stock	Size of Drills and Bits in Stock	Test Pumps in Stock	
					Centrifugal	Diaphragm

GRAVEL FILTER WELLS

Concern	Rigs and Caisson in Stock	Screens in Stock	Caisson in Stock	Blank Caisson in Stock	Test Pumps in Stock	
					Centrifugal	Diaphragm

appears to be worth mentioning because of its possible far-reaching effect. This was a case where the local water works official "requested" that his personnel refrain from signing up with the local state guard unit resulting in the following quotation from our Massachusetts Laws being called to his attention:

CHAPTER 425 SECTION 56 ACTS OF 1939

An act revising the military laws of the Commonwealth

Whoever *willfully* deprives a member of the organized militia of his employment, or *denies* him employment, or prevents his being employed by another, or obstructs or *annoys him* or his *employer,* in respect of his trade, business or employment, because of such member's connection with the organized militia, or because of his necessary absence from business in performance of his duty as such, and whoever dissuades any person from enlisting in the organized militia by threat of injury to him in respect of his employment, trade, or business, or of other injury, if he shall so enlist, shall be punished by a fine of not more than $500.00 or by imprisonment for not more than six months or both.

The author feels that the local water works official used good judgment. Obviously a water works man connected with state guard units in time of emergency would be less useful to the community than if he remained in the position for which he has been specially trained and in which he cannot be readily replaced. Because of the importance of this question the author is taking the matter up with the office of the Adjutant General.

Another matter that has caused some concern to us in working out our plan is the matter of possible shortages of water supply materials especially chemicals used in water treatment. The present plan of taking care of shortages through the Office of Production Management would be too cumbersome in case of emergency. Certain of these chemicals should be available for rapid distribution. To care for this situation Frederick S. Gibbs of Wallace & Tiernan Co., Inc., Coordinator of Supply of Water Treatment Chemicals, has formulated a plan whereby a *very limited* amount of such chemicals would be kept under consignment by the manufacturers at emergency depots, to be drawn upon only with the approval of the Department of Public Health and only in case of emergency and to be charged when so drawn to the municipality by the manufacturers making the consignment. Such an emergency depot would in Mr. Gibbs' opinion take up but little space.

Informally this plan appears to have the approval of the local office of the OPM.

Summary

The Commonwealth of Massachusetts under His Excellency the Governor and the Adjutant General has a well organized state emergency plan. It is a military plan and is organized to function under the Governor as Commander-in-Chief in any emergency whether it be the results of a conflagration, flood, hurricane, or attack by enemy forces. It operated during the hurricane, flood, and tidal wave of 1938 and has since been expanded to include the advice and assistance of all state departments, municipal departments and military civic and welfare organizations.

The Department of Public Health functions under this plan, not only through all the personnel and facilities of the department but also by having its chief engineer a member of the state military staff.

As a part of this plan, leading water supply officials of the state have been appointed civilian members of the state staff with the title of Water Supply Coördinators. Through the activities of these coordinators the systems of water supply of the state have been adequately mapped, material and equipment are being inventoried, and facilities are being provided to render aid from one water department to another and to overcome subversive activities or sabotage in any way that may have an unfavorable effect upon the public water supply. To assist in the procurement and distribution of water supply equipment, materials and chemicals, two civilian water supply coördinators have been appointed from the ranks of the manufacturers to work under the State Emergency Plan.

Any emergency plan must have a working organization in order to function properly. Massachusetts has both the plan and the organization and has authority under the military laws of the Commonwealth to function effectively.

Discussion

Frederick S. Gibbs.[1] Unprecedented defense uses for the chemicals employed in water treatment now confront the water supply officials with problems never before experienced. The State Emergency

[1]Wallace & Tiernan Co., Inc., Boston, Mass.

Plan has anticipated these problems and stands ready to provide assistance in the speedy procurement of the necessary chemicals in case of emergency.

Today chlorine has been added to the growing list of chemicals for which a priority rating is required. Recognizing the importance of water supply chlorination in the maintenance of public health, government officials have placed the supply of chlorine for water treatment at the top of the list of civilian uses. Every water utility is entitled to an A-10 priority rating in its purchases of chlorine. Other chemicals used in water treatment have not as yet been placed on priority lists. However, shipment delays have already been experienced. It is to eliminate these delays and uncertainties that the State Emergency Plan has incorporated all water treatment chemicals in the coördination plan formulated for emergencies.

Recently all water utilities in the Commonwealth received a request from Mr. Weston for confidential information on the amounts of chemicals used and by whom supplied. It is imperative that this information be returned to him without delay. Upon receipt of this information, it is planned to set up a State Emergency Depot containing emergency stocks of chemicals. The emergency chemical stocks will be held for exactly what the name implies: emergency use. If any water utility in the state cannot obtain the necessary chemicals from any other source, the emergency depot will fill in the breach until the chemicals can be obtained from the normal sources.

It is recognized that many water utilities are not now using chemicals and do not have contacts with chemical suppliers. In case of a sudden emergency today, it would be practically impossible for these utilities to obtain the necessary chemicals in a hurry. Neighboring municipalities, with their present day-to-day stocks, would be unable to help. The unfortunate stricken communities must have chemicals immediately made available for them. Our excellent public health records could overnight take the toboggan slide of a water-borne epidemic if every water supply is not given the protection of a state stock of chemicals.

The State Emergency Depot is being established for the protection of every water department or water company. In past flood and hurricane emergencies, the Grace of God, and good luck in securing chemicals from commercial stocks brought us through with our Common-

wealth public health records unblemished. In these days of national and international emergencies, we hope that the Grace of God will not forsake us. The commercial chemical stocks are forsaking us. We can no longer depend on luck in obtaining emergency chemicals. The State Emergency Depot may very well be our salvation if we are beset with future emergencies.

WARREN J. SCOTT.[2] There is very little that can be said in discussion of the subject matter of Mr. Weston's paper beyond the statement that Massachusetts has apparently set up a splendid organization to combat disasters that might adversely affect public water supplies in peace-time or in war. Following the example of the fellow who wants to talk about his own operation after hearing about yours, I might say a few words as to what is going on in Connecticut.

The Connecticut Water Works Association over a year ago at the suggestion of the State Department of Health appointed a Defense Committee which consists of G. E. Lourie, Superintendent of the Bristol Water Department, as Chairman, and representatives of water utilities in Ansonia, Bridgeport, Groton, Hartford, New Haven, Stamford and Waterbury, and a representative of the State Department of Health. The area of Connecticut is small and the actual division of the state into water supply districts has not appeared necessary to date although the committee well represents most of the geographical sections.

I note that Mr. Lourie on Friday is scheduled to discuss some of the activities of his Committee so that I will not trespass too far on his subject. However, I might mention that while the Committee has no official status as in Massachusetts, it has had a number of meetings, has sent out numerous communications to Connecticut water works officials and can readily be incorporated in a more formal manner into the state defense set-up. It includes representatives of all the larger water utilities and of those which are centers of defense industries. Connecticut has been termed an arsenal of the nation and is extremely busy on defense production.

The Connecticut State Department of Heatlh beyond maintaining a central stock inventory in coöperation with the committee, which can be retaken as emergency conditions develop, has also been attempting

[2]Chief, Bureau of Sanitary Engineering, Connecticut State Department of Health, Hartford, Conn.

to promote the provision of emergency chlorination equipment, to ascertain the possibilities of inter-connections between public water supplies, to survey the availability of private sources of supply and necessary equipment to make such supplies available, to review means of safe by-passing of usual treatment facilities, and to review steps to combat interruptions of power. The Public Utilities Commission has been active in discussing with Connecticut water utilities methods of protecting water works properties against sabotage or other damage. In Connecticut a State Defense Council has been established by law to coördinate various civilian defense activities.

In the report of our committee on committees yesterday, it was suggested that rather than have this Association duplicate the defense activities which seem best adapted to state organizations in this field, an informational committee be set up composed of members selected from each of the water works defense committees in the various New England states and that this Association promote the formation of water works defense organizations in each of the New England states, should they not now exist. May I suggest to the President, if time permits, that it would be of interest to call upon one representative each from Maine, New Hampshire, Vermont and Rhode Island to learn whether a state committee or organization has been appointed and urge that the names of the committee personnel be forwarded to the President so that a committee may be appointed in this Association to exchange information.

ROGER W. ESTY.[3] Mr. Weston appointed me Civilian Assistant Water Supply Coördinator for the Northern District of Massachusetts which comprises Essex County and most of Middlesex County. It has been a very interesting experience to organize the water works men in these two areas and also to work on inventories in my own territory.

Through Mr. Weston we received a copy of an inventory form that was sent out by the American Water Works Association. That particular form, when it first arrived, seemed to call for a big job. Those who keep annual reports could refer to them as to how much pipe, and how many hydrants, gates, and meters were used during the year. From these reports, we easily took the quantities requested by

[3]Superintendent of Water Works, Danvers, Mass.

the A.W.W.A. We had in these districts 36 cities with a population of 800,000 or over from which to obtain this information. In a very short time we had reports back from 31. I think that this was a very remarkable showing, considering that water works men are always busy. The taking of inventories requires a lot of time. I know that from my own experience.

Mr. Weston also appointed three other men in Essex County and Middlesex County to assist in compiling this information. Mr. Duffy, Superintendent of Public Works of North Andover was selected to take care of Essex County. Since this county is so large, I offered to help him out by taking care of the southern part of Essex County. Mr. Duffy had considerable experience during the flood of 1936 and probably was best qualified to get out these data; also telling us of his experiences at the time of the flood in trying to supply the city of Lawrence with water when their filtration plant went out of commission. James H. Reynolds, Assistant Superintendent of the Lowell Water Works, was assigned the northern part of Middlesex County and Mark E. Croker, Superintendent of Distribution of the Newton Water Works, the southern part.

It was asking a lot of these gentlemen to visit all of the water works superintendents. It takes time as I experienced myself. You may say that one can visit a water works man in an hour. Try and do it. One gets to talking shop and spends half a day easily. I suggested to my assistants that we hold a meeting in each district and that we request the water works men to come to us. Our first meeting was held in Peabody, centrally located in Essex County. Invitations were sent out and 75 per cent of the men reported—a very fine showing. Not only did the superintendents come but they brought a member or two of their boards, the town or city engineer, a foreman, or some other individual interested in the local water department. We requested that each town be represented by someone, as we had a lot to tell. Mr. Duffy outlined our plans, and Francis Kingsbury and Edward Sullivan represented the Department of Public Health. The various speakers outlined what the water works men should do, particularly about inventories of their stock and equipment.

It was quite a job to procure this information, but everyone cooperated, and we soon had all inventories in. I am happy to announce that Mr. Duffy has his district completed.

In Middlesex County the meetings were held at a later date. A meeting was held in Lowell with Mr. Reynolds presiding and assisted by Messrs. Kingsbury and Sullivan. Very shortly after this a third meeting was held in Cambridge. Mr. Croker presided at this meeting and was assisted by Messrs. Kingsbury, Doggett, and Sullivan.

In most cases the reports are coming in very nicely. We have sent out another letter in these two counties asking that the information be reported by October 1st.

Already I have had requests in my district to know whether or not we can get some left hand gate valves and some 4-in. pipe. It was astounding to learn of the small amount of 4-in. cast-iron pipe on hand in Essex County. No one seems to have more than 200 ft. of 4-in. cast-iron pipe in stock. Of course there are a lot of systems that have got a lot of old 4-in. cast-iron mains in service, and if we ever have trouble, they will need 4-in. pipe to make repairs.

Another important duty relates to physical connections with other cities and towns. It is very important to be able to obtain water from some one else if one's own supply gives out. That was illustrated very well at the time of the 1936 flood in Lawrence when the Lawrence filtration and pumping plant went out, and North Andover, Andover, Methuen and Salem, N. H. supplied the city of Lawrence with water. So you can see that even small places and connections may be valuable and important. You never can tell when the little fellow will be the big fellow, as he was in that particular instance.

Gate valves too are very important, and we should make sure that they are usable. I visited a place not long ago where they were closing a 12-in. valve. It took four men to do it. No 12-in. gate valve should require four men to close it, nor even two. It should be an easy job for one man. Those gates should be taken care of to see that they operate easily. Also several men in each department should know where these connections are. Supposing you were taken away or sick, there should be someone available and well informed, so that he could carry on in your absence.

MR. SCOTT. I would like to ask Mr. Weston one question. In setting up this organization in which the superintendents of the various water departments are assigned to specific duties, and presumably may be called away by the state organization from their local duties in times

of disaster, I wondered whether there was any local objection to that type of arrangement.

MR. WESTON. I suppose that would be best answered by the coördinators themselves. As far as I know there has not been any local objection. As a matter of fact, I know in the case of one coordinator, his board of water commissioners has been sufficiently generous to permit him to use the town's car to go out and visit some of the other superintendents.

MR. SCOTT. I do not mean now; I mean in the future. Suppose we get into a war setup where they take the superintendent from the community.

MR. WESTON. If you will notice, we took the very largest places from which to take our coördinators. In these places, as a rule, there is a pretty good man who has worked under the superintendent. He is the man who would be left in charge of work when the superintendent goes on his vacation. We do not predict any difficulty in that regard.

HAROLD L. BRIGHAM.[4] There is one thing I would like to bring out. It does not particularly affect my own community, but the question has been asked me. We were instructed by the representative of the State Plan to give out no information to anybody unless they had the proper credentials. In most of the communities of Massachusetts, at least, there are patriotic organizations which are working under other state defense plans, particularly the ARP, and in some cases some rather overzealous persons seem to think that they should have certain plans, information, tools, and so forth, to cope with so-called emergencies which should be left to the various utilities. I was recently called by a neighboring superintendent who told me that his ARP committee was having a meeting that night and that they demanded the plans of his water works and wanted gate valve wrenches and hydrant wrenches, and so forth. He asked me what I thought he should do. I felt that he was in a rather ticklish position and could not very well refuse outright but that he might back himself up by saying that if the Adjutant General's Office said it was all right for him to give the things asked for, he would do so. Could Mr. Weston give us any information on that particular subject?

[4]Superintendent, Marlboro, Mass.

MR. WESTON. I think the answer is that your local committee is not organized properly. When the Governor's public safety committee was established it was supposed to act only in communities—like I have mentioned, with an organization similar to that in England and Scotland—that organization to act only in the municipality itself. It is to render aid primarily, in the beginning at least, to existing local authorities. The subcommittee on water supply in that community should be headed up by the superintendent with the thought that it would give additional help to that superintendent, so that in the case of bombardment, or other emergency, and with the possible loss of his labor force or assistants, somebody might come in there with some training and help him. This is a lot better than starting with nothing.

We recognize that cases like that referred to by Mr. Brigham may exist and for that reason I spoke to Mr. Churchill, who heads up a section of the Governor's Committee on Public Safety. The result was that I got another job out of it. He placed me in charge of one of his committees on water supply. The reason I went to him was this: There was a case where a woman went to a water department and gave a blanket order for all the plans and all the records, and whatnot, of that water department. The superintendent told her that that was quite a big order, and asked her what she was going to do with these records after she got them. She admitted she didn't know. It is to prevent that sort of thing, that instructions have gone out now to the local committees that the committee on water supply under a defense program must be headed up by the local water works superintendent.

MR. BRIGHAM. When the first students went to the ARP course that was given in Boston, meetings were held by the local defense committees. One of the first things they wanted was a large-sized map that would show every water pipe, sewer pipe, hydrant, gate valve, and so on, in the utility. Our chairman, who had had considerable experience in other matters, such as relief, sat down and talked with the man and told him that it was almost impossible to give him this information, and that even if he did have it it would not be of any particular value to him. Hence we worked out a scheme practically the same as outlined by Mr. Weston, whereby all calls that affect the water and the sewerage system would be handled on our local board of control by the superintendent, who was on that committee. The ARP would represent only the labor battalion, so to speak.

WATER WORKS OPERATIONS UNDER EMERGENCY CONDITIONS

BY HARRY E. JORDAN*

[*Read September 24, 1941.*]

Public water supply is an essential civilian service. It is a part of the defense mechanism and may be the life, or its lack the death, of a city under attack. The problems facing water works managers in time of war are manifold. They may be grouped under four principal categories: maintenance of personnel for service; protection against sabotage; repair of damage caused by acts of war; and procurement of materials necessary to maintain service.

However casual may have been the method of recruiting personnel in times past, now is no time for water departments to employ persons who are un-American in their attitude and non-coöperative with their employed associates. Each employee of a water department should be investigated to the fullest possible extent so that his various affiliations and activities are recorded. Non-citizen employees require special handling. Steps which they may have taken toward the completion of citizenship should be respected and encouraged. Lack of progress toward naturalization should be grounds for suspicion and possible dismissal. An employee whose attitude is known to be non-coöperative or disloyal to American interests should be detached from the service. Promotion of a proper attitude among the employees requires equivalent qualities among those whose duties call for leadership in water department operation.

There is at present an unnecessary confusion in this country related to employee organizations. The encouragement which is being given to employees in industry to organize for group benefit has at times gone to the extent of promoting or at least condoning minor civil war between rival groups—while the employer or the executive is helpless to intervene. No one who looks at public service as service to the public can rationally encourage employee group methods of advancement which interrupt the service intended to be rendered. In a

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nation organized to advance the rights of some individuals or groups, it is a fallacy to injure many individuals by permitting public service to be "struck" as a step in a wage or organization conflict. It is a confession of our complete failure to govern ourselves. Of all times, a time of war and defense emergency must be the time that public service personnel stays on the job and keeps the service going. Our British water works contemporaries have for many years brought their employer-employee relationships into discussion across the conference table. Let us hope that we profit by the example of their employee-employer relationships and avoid the confusion that will develop if the present attitudes of some labor leaders influence the men who are working in water works and the other public services.

This confused labor situation makes it difficult to deal effectively with acts of sabotage: the second category of problems facing the water works executive. Was the Kansas City electric power cut-off a strike or an act of sabotage? Ostensibly it was a strike—a wild cat one, to be sure. But how sure are we that it was not sabotage? Was it a practice operation, just as some of the Allis-Chalmers union technics were essentially sabotage of production?

This is a critical problem, because all who have studied subversive activities agree that the most effective saboteur is the trusted employee. The stranger with dark glasses and whiskers has a hard time getting into a place where he can do harm, but "Oscar Smith" who has worked on the job for five years generally goes about where he pleases. The first line of defense against sabotage is an informed and aggressively loyal employee group.

Every employee in a water plant today should be identifiable. Today in Washington we see men of the highest type walking about the streets and buildings with photo-identity cards pinned on the outside of their coats. The cards bear distinctive colors to show the division of service in which the man is employed. With this in mind, and with the information already available concerning the production and content of such identity cards or badges, there is no excuse for any water department's failure to take this first step in defense against sabotage.

The second step is the requirement of visitors' permits. Already widely practised, its universal extension into the water supply production or stores area is clearly indicated. Some plants do not permit even the duly accredited visitor to wander about alone. Others do not

permit strangers' automobiles inside works areas. It has been a good public relations policy to encourage visiting at water works plants. Today it is a better public relations policy to restrict visiting and let the customer know it. He will really appreciate it and feel that he is being properly protected. In fact, given half a chance, he will help guard the property.

The third category of problems facing water works operators in time of war includes those directly related to acts of organized warfare. They may result from air raids or from artillery fire and mass invasion. The results of direct military attack along the traditional lines are not new. "Carthago delenda est" described the fashion of the destruction at the hands of the ancient Roman armies and may be the fashion of ultimate action anywhere today.

Air raids are a new problem and they bring home to people, at their daily work and in their homes, many of the destructive effects of front line action. The results of air raids are not uniform. They vary inversely as the effectiveness of military defense. Overseas experience has indicated that well organized anti-aircraft defense can keep enemy planes flying so high that definite objectives in the defended area can not easily be hit. In such cases, air-bombing becomes a random operation, and the hits upon certain types of structures, such as pumping stations, filters, and mains, become a matter of simple area–probability.

Distribution mains, the most widely dispersed components of a system, are the most frequently injured parts of water works property. With reasonably effective air defense, the breaks in water mains may develop at the rate of one per hundred miles of mains per day. With inadequate defense, the rate of breakage may aggregate one per mile of main per day. In the first case, emergency repair crews can be organized and equipped so that reasonable service can be maintained. In the second case, the task is hopeless. Assuming the existence of good air defense, the water works manager faces the problem of organizing repair crews, providing equipment and obtaining repair material. So much definite record of British experience in these matters is already available that nothing more is proper now than the suggestion that it be read and digested. This must be emphasized: crews and repair stores must be dispersed, not centralized. Emergency communication arrangements must be perfected. With these effective, the crews can be called to the points where they are needed and the

material they require can be made available to them. It is clear folly to put them all in one spot and take the chance that all may be blown up by one bomb. It has happened.

Among water departments in a region, plans for the exchange of materials and men are proper. Already in several states, such plans for coöperative action have been made. The details vary and doubtless will continue to vary, especially if the defense of water supply becomes as essential here as it has been in England. Here again a word of warning is necessary. Regional stores depots have apparent value. But they involve two dangers. One is the creation of a sense of security to the operator of a single property which would be more real if he maintained his own reasonable stock of materials. The other is the danger common to all central stores—the chance of their being in the area of destruction of a single bomb. "Don't put all your eggs in one basket" is more than a trite proverb.

The final type of problem—procurement of materials—is with us all these days. There is so much to say, so much better left unsaid, and so great need for good judgment and discernment that one knows hardly what may properly be included here. One thing must be understood. The conditions today may be upset tomorrow. Today's rules may be tomorrow's tradition. Therefore, much discussion of today's details may simply be wasted paper next week. The primary fact to keep in mind is that the planned defense production for the fiscal year 1941-1942 approaches an 18 billion dollar volume. That equals the total industrial production in the U. S. in 1929. A recent statement indicates that the defense expenditures are at a rate less than 20% of the national income. Britain's war expenditures approach 50% of her income. Germany's is reputed to be at least 60%. This naturally bears as its corollary that civilian supplies must be less plentiful. One recent comparison[1] of the total output for 1940 with the forecast total output for 1943 is of interest. Against 82.2 billion dollars as a total for 1940 the estimate for 1943 is 110 billion dollars.

Food, housing, and clothing totalled 55.2 billion dollars in 1940 against an estimated 55 billions in 1943, nearly equal in dollars but a per capita reduction when population increase is taken into account. Consumers durable goods were 8.3 billion dollars in 1940, but will be only 4 billions in 1943; and plant equipment and inventories 9.2 against

[1] E. E. I. Bulletin, July, 1941, p. 293.

12. National security takes a striking rise from a 5 billion dollar output in 1940 to a 35 billion dollar total in 1943.*

All of this means that materials must be diverted from their traditional and accustomed channels to new paths of production. So we have the priorities system. This is simply a method of assigning to certain emergency groups the power to establish preferential lines of travel for scarce materials. It implies that first consideration is to be given to direct defense, that certain civilian activities are to be preferred over others, and that producers of luxury and non-essential materials will either be drastically restricted or put out of business "for the duration". This last is an unpleasant prospect. It is heart breaking and business breaking for some. Counter to it is the fact that the tremendous expansion of military production will require all the men and many of the facilities now employed in the displaced industries.

In the beginning, we agreed that public water supply is an essential service—that it is necessary for defense. No one can question the fact that defense production in any industrial center requires adequate water supply, fire protection, and good health conditions. These things the modern public water supply system provides. Those in authority recognize this special status and are, as rapidly as administrative procedures can be established, defining the preferred position in procurement to be held by water, electric, gas, heating, and sewer systems. The Maintenance, Repair and Operation order (P-46) sets up certain preferred positions for these services.

The Project Rating System makes it possible for a major water works extension required to supply defense industry, housing, or training centers to be given adequate preferential rating, so that the work can be done and the service rendered. The method of applying for preferential rating for a single or group of similar items still stands. The uses of the Project Rating System, the P-46 Maintenance order and the PD-1 application form are all recorded in memoranda that have been widely circulated and need not be discussed fully here.**

At the present moment, there is not enough of some materials, such as pig iron, to meet all the needs of "defense" rated orders. There are clear evidences of overbuying, hoarding, and lack of timing in placing orders which have adversely affected current conditions. The

*This estimate must now be revised as a result of plans for military production in 1942-43 totaling more than 50 billion dollars.

**After March 1, 1942, form PD-1 will be superseded by form DP-1A.

armed services have not been free of these faults, and their actions in some cases have severely dislocated civilian allocation of such materials as chlorine and chlorine products. But no actual interruption of use of chlorine on public water supply is yet recorded. For this, the field of public sanitation has the Chlorine Institute to thank. But much progress is being made, and with the restriction of production of certain consumer luxury goods as well as adjustments in the priorities and allocation procedures, the ferrous and non-ferrous metals will flow more freely into the uses for direct defense and for defense-related needs such as public water supply.

There is much talk of use of substitute materials or materials giving a shorter time of useful service than the standard specification materials. The defense housing priorities procedure clearly excludes certain scarce materials and gives preference to the use of many shorter-lived materials. No group should be more conscious of this possibility than the army and navy personnel. Regrettably, much high grade long-life specification material has gone into army camps and the like. Regrettably also, civilian long-term requirements are now being shunted off into the inferior or substitute material. There are many useful substitute materials. Many can be used in water supply. The metal in some of the materials that have only been available for use in the past ten years can be devoted to more imperative needs. Water plants can again get along with many things they formerly found satisfactory, which have, in recent peace-time years, been displaced by newer, higher grade materials. But there is every reason why temporary military projects should also be adjusted to the same pattern. There is simply no sense in the laying of heaviest grade pipe in a temporary training center and allowing permanent public water supply only secondary, light weight, or short-lived material. This is a practical attitude involving payment by "the Public" for material used in either case. The citizens should get the most for every dollar they are having spent for them in permanent structures and services and not invest in 100-year material for use in a 10-year-life project.

Water works men in the United States have again demonstrated their fine qualities. They are anxious to meet every defense demand. They are trying to keep their properties in order and ready to give the service that is so vital. All through the present emergency they have shown themselves loyal, coöperative citizens trying to do their part in this vast national enterprise.

WATER CHARGES TO MUNICIPALITIES IN THE BOSTON METROPOLITAN AREA BY THE METROPOLITAN DISTRICT COMMISSION

BY KARL R. KENNISON*

[*Read September 25, 1941.*]

In the following pages is presented an analysis of the cost of the water supply developed by the Metropolitan Water District and the opportunities that are offered to other municipalities to join the District. The District was organized about 46 years ago as a result of legislation in Chapter 488 of the Acts of 1895. Of the 20 cities and towns now in the Metropolitan Water District, all were in the original District or admitted prior to April, 1903, with the exception of Swampscott, admitted in 1909, and Brookline, admitted in 1925. Table 1 shows the condition attending the entrance of each of the member municipalities.

In discussing the growth of the District, population, water consumption, etc., it is more satisfactory and informative to consider all these 20 municipalities as a unit, as though they were in the District from the start. In 1895, their population totalled 781,594, and last year's census showed 1,509,376, or nearly double. Their consumption in 1895 was 70.82 m.g.d., and this year, judging from the average of the first seven months, it will be about 154 m.g.d. Although this has more than doubled, the rate of increase was high in the earlier years but very little in recent years, particularly since the period of depression which commenced in 1929. During the entire period, there has been but little net increase in the consumption per capita, due, of course, to the installation of meters. Table 2 shows the growth of these 20 cities and towns within the past 35 years and the fluctuations year by year in the demand for water.

A number of important reports have been published covering the District's need for the original development and for its extension. The first was a report of the State Board of Health to the General Court upon a Metropolitan Water Supply, published as House Docu-

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TABLE I.—CONDITION ATTENDING THE ENTRANCE OF EACH MEMBER MUNICIPALITY INTO THE METROPOLITAN WATER DISTRICT

Municipality	Entrance Legislation Year	Chapter	Date of Entrance	Date when Supplied	Remarks
Arlington	1895	488	Jan. 31, 1899	June 30, 1899	Entrance fee, $15,000 and property valued at $15,000
Belmont	1895	488	1895	Nov. 30, 1898	In original district
Boston (including Hyde Park)	1895	488	1895	Jan. 1, 1898	In original district
Brookline‡	1895	488	Jan. 1, 1925	Jan. 1, 1925*	Entrance fee, $400,000
Chelsea	1895	488	1895	Jan. 1, 1898	In original district
Everett	1895	488	1895	Jan. 1, 1898	In original district
Lexington	1895	488	Feb. 13, 1903	Jan. 24, 1903	Entrance fee, $27,250
Malden	1895	488	1895	Jan. 21, 1898	In original district
Medford	1895	488	1895	Mar. 12, 1898	In original district
Melrose	1895	488	1895	Jan. 1, 1898	In original district
Milton	1902	307	Mar. 10, 1903	Feb. 28, 1902	Entrance fee, $10, previous payments by Milton Water Co. being consideration in part for admittance
Nahant	1895	488	Sept. 13, 1898	June 29, 1899	Entrance fee, $20,000 and an annual payment of $800 until Swampscott shall begin to buy water
Newton	1895	488	1895	†	In original district; takes no water; pays an annual standby charge
Quincy	1895	488	June 24, 1897	Dec. 31, 1898	Entrance fee, $5
Revere	1895	488	1895	Feb. 9, 1898	In original district
Somerville	1895	488	1895	Jan. 1, 1898	In original district
Stoneham	1897	473	May 23, 1901	Oct. 21, 1901	Entrance fee, $30,000
Swampscott	1908	560	May 3, 1909	June 29, 1899	Entrance fee, $90,000
Watertown	1895	488	1895	Nov. 30, 1898	In original district
Winthrop	1895 1898	488 295	June 29, 1898	Feb. 9, 1898	In original district, but membership confirmed by act of 1898

‡See 1924, chap. 276 Bonds; and 1925, chap. 308 Reimbursement for Water.
*Emergency supply furnished at times for a number of years.
†Emergency supply furnished upon demand.

TABLE 2.—GROWTH OF THE TWENTY CITIES AND TOWNS NOW IN THE METROPOLITAN WATER DISTRICT

(With the exception of Swampscott, admitted in 1909, and Brookline, admitted in 1925, all were in the original District or admitted prior to April 1903.)

		Consumption including supply from local sources		Consumed by members taking their entire supply from the District—m.g.d.	Demand on District sources, including sales, etc.—m.g.d.
	Population	m.g.d.	g.p.d. per capita		
1905	975,077	122.13	125.3	116.08	117.96
1906	.....	122.83	122.9	117.03	118.17
1907	.....	129.88	126.8	123.67	124.81
1908	.....	131.27	125.1	124.92	126.07
1909	.....	124.89	116.5	119.12	119.84
1910	1,098,048	118.22	107.6	112.09	112.96
1911	.....	116.09	103.1	110.00	111.37
1912	.....	121.59	105.5	116.23	117.39
1913	.....	109.45	92.7	103.85	104.91
1914	.....	112.88	93.5	107.04	108.45
1915	1,234,790	107.52	87.1	101.94	103.13
1916	.....	112.28	90.1	106.34	107.46
1917	.....	116.23	92.4	110.03	111.36
1918	.....	136.33	107.5	129.76	131.28
1919	.....	127.39	99.6	120.59	121.81
1920	1,290,651	134.40	104.1	127.27	128.65
1921	.....	124.69	95	117.41	118.74
1922	.....	126.74	95	119.27	120.74
1923	.....	133.04	98.1	125.24	127.25
1924	.....	132.18	96	124.10	126.84
1925	1,398,702	136.52	97.6	128.35	134.50
1926	.....	138.65	97.8	130.18	134.60
1927	.....	141.15	98.2	132.49	136.18
1928	.....	144.44	99.1	135.69	139.59
1929	.....	146.51	99.1	137.04	142.27
1930	1,498,253	146.11	97.5	136.42	143.11
1931	.....	144.57	95.8	134.78	138.09
1932	.....	137.68	90.7	127.99	131.48
1933	.....	134.39	88.0	125.07	128.64
1934	.....	143.14	93.2	133.64	137.17
1935	1,548,282	140.71	90.9	131.13	135.15
1936	.....	143.48	93.1	133.65	137.72
1937	.....	140.29	91.5	130.84	134.85
1938	.....	139.40	91.4	130.18	133.68
1939	.....	145.44	95.9	135.39	140.48
1940	1,509,376	149.16	98.8	139.17	143.51
1941	(7 months)	154.3	102	143.9	148.4

ment No. 500 of 1895, which included the report of Chief Engineer, Frederick P. Stearns. The next was a report of the State Department of Public Health and the Metropolitan District Commission to the General Court upon the Water Supply Needs and Resources of the Commonwealth, published as House Document No. 1550 of 1922, which included the report of Chief Engineer, X. H. Goodnough, to the preparation of which the author was privileged to contribute. Another was a report of the Metropolitan Water Supply Investigating Commission to the General Court, published as House Document No. 900 of 1926, which included the report of the Commission's engineer, Allen Hazen. One of the most important and instructive recent legislative documents was the report to the General Court by the Metropolitan District Water Supply Commission and the Department of Public Health Relative to Improvements in Distribution and to Adequate Prevention of Pollution of Sources of Water Supply of the Metropolitan Water District, published as House Document No. 262 of 1938.

Summarizing the information as to the safe yield of the supply, the original Wachusett-Sudbury-Cochituate sources developed a total watershed area of 211.0 sq. miles, 80 billion gallons of storage, and a safe yield of about 165 m.g.d. This included as the principal source the Wachusett Reservoir with 118.2 sq. miles, 65 billions gallons of storage, and about 130 m.g.d. of safe yield. Since that time, not only a great deal of water has run over the dam, but many things have happened to the supply. A considerable population with its attendant industrial development has encroached upon the Sudbury watershed, particularly the Southern Sudbury, a portion of which has been salvaged for emergency use by the construction of pipe lines diverting the flow from some of the better upland areas northerly into the main Sudbury Reservoir. A similar encroachment has made the entire Cochituate supply of very doubtful value for some time past. In addition to direct pollution of these older, smaller reservoirs, a great deal of pollution has found its way into the old grade-line Sudbury and Cochituate aqueducts. Furthermore, the main drainage area of the Wachusett Reservoir has been materially reduced by necessary diversions to take care of the needs of the city of Worcester. As a result, when the District had finally developed its new sources on the Ware and Swift rivers, its sources of good quality in the Wachu-

sett and North Sudbury areas had been reduced to 135.0 sq. miles, 74 billion gallons of storage, and about 119 m.g.d. of safe yield. To be sure, a small additional supply could be obtained by resort to emergency methods but hardly enough to offset the fact that Worcester was recently sold the right to divert an additional 10 m.g.d.

If any further evidence were needed as to the necessity for extending the sources of supply to the Ware and Swift rivers, it can be obtained readily by noting the record of the depth to which Wachusett Reservoir has been drawn in periods of drought. In 1927 about the time the construction of the new supply was started, Wachusett Reservoir had dropped about 32 ft. in three years. In 1931, just prior to the securing of the first additional supply from the Ware River, Wachusett Reservoir had dropped about 46 ft. in two years. We do not happen to have had any period of drought since then until recently. However, in spite of the large quantities of water which were unavoidably wasted over the spillway in floods of a few years ago, Wachusett Reservoir has dropped 29 ft. in the last 15½ months (see Fig. 1). The important difference, however, is that this recent drop has caused no concern, because Quabbin Reservoir was completed two years ago and already has stored 50 per cent more water than Wachu-

FIG. 1.—WACHUSETT RESERVOIR BOTTOM, AT THE DAM, SEPTEMBER 17, 1941; 33 BILLION GALLONS IN STORAGE OF WHICH ABOUT 13 IS SAFELY AVAILABLE

sett could hold, if full. The recent drop in Wachusett Reservoir has been permitted merely in the interest of conserving the supply in order to provide as much storage as possible for catching any fall rains that might have come. Since none such have materialized, the gate on Quabbin Aqueduct was opened a week ago and Quabbin Reservoir is now discharging at the rate of approximately 480 m.g.d. into Wachusett Reservoir (see Fig. 2).

FIG. 2.—PORTION OF QUABBIN RESERVOIR SEPTEMBER 17, 1941; 101 BILLION GALLONS IN STORAGE OF WHICH ABOUT 91 IS AVAILABLE

The new Ware-Swift supply has added drainage areas totalling 282.8 sq. miles, 415 billion gallons of storage, and a safe yield of 210 m.g.d. It could have been developed much more rapidly if the needs of the District had so justified. However, the recent business depression and consequent reduction in consumption has made it possible to develop the supply in progressive steps, thus conserving the District's funds and materially reducing the peak of assessments.

The entire cost of the supply both old and new is paid through annual assessments which the State Treasurer includes as part of the state tax against all municipalities in the District, the total assessment being sufficient to take care of all payments of principal and interest on the water bonds, current maintenance, and all direct expenditures

TABLE 3.—ANNUAL ASSESSMENTS OF THE METROPOLITAN WATER DISTRICT

	For Maintenance and all other Expenditures except Capital Expenditures	For Bonds, all Principal and Interest and Pay-As-You-Go Capital Expenditures: Construction, by Metropolitan District Commission, of Old Supply and Distribution Works	For Bonds, all Principal and Interest and Pay-As-You-Go Capital Expenditures: Construction, by Metropolitan District Water Supply Commission, Principally New Supply and Pressure Aqueduct	Total
1926	$769,799	$2,143,553		$2,913,352
1927	847,554	2,244,488	$1,000,000*	3,092,042
1928	886,454	2,480,132	82,570	3,449,156
1929	825,574	2,318,569	432,697	3,576,840
1930	892,908	2,246,158	821,193	3,960,259
1931	966,102	2,292,221	953,919	4,212,242
1932	926,934	2,273,459	1,247,973	4,448,366
1933	857,624	2,079,536	1,504,215	4,441,375
1934	867,723	2,151,377	1,763,390	4,782,490
1935	936,450	2,207,172	1,908,122	5,051,744
1936	920,920	1,672,720	2,186,798	4,780,438
1937	995,701	1,673,091	2,330,962	4,999,754
1938	986,796	1,478,435	2.540,341	5,005,572
1939	972,866	1,364,016	2,500,173	4,837,055
1940	986,385	1,226,527	2,573,033	4,785,945
Estimated				
1941	1,011,170	1,031,258	2,637,227	4,679,655
1942	1,040,435	690,960	2,636,605	4,368,000
1943	892,246	637,225	2,800,529	4,330,000
1944	904,324	537,800	3,064,876	4,507,000
1945	801,268	459,020	3,393,712	4,654,000
1950	828,948	195,073	3,118,979	4,143,000
1955	905,766	144,160	2,805,074	3,855,000
1960	833,960	129,100	3,163,940	4,127,000
1965	854,602	50,000	2,516,398	3,421,000
1970	906,937	50,000	1,345,063	2,302,000

*Paid by Worcester, in cash, for a portion of the Wachusett Watershed and hence not included in total assessment.

year by year. The cost is apportioned among the various municipalities, two-thirds on the basis of consumption and one-third on the basis of valuation. With certain exceptions, all new construction is financed by bond issues, so that the District has a considerable water debt which it is continually paying off and which any new municipality that may join the District now will share. Also,

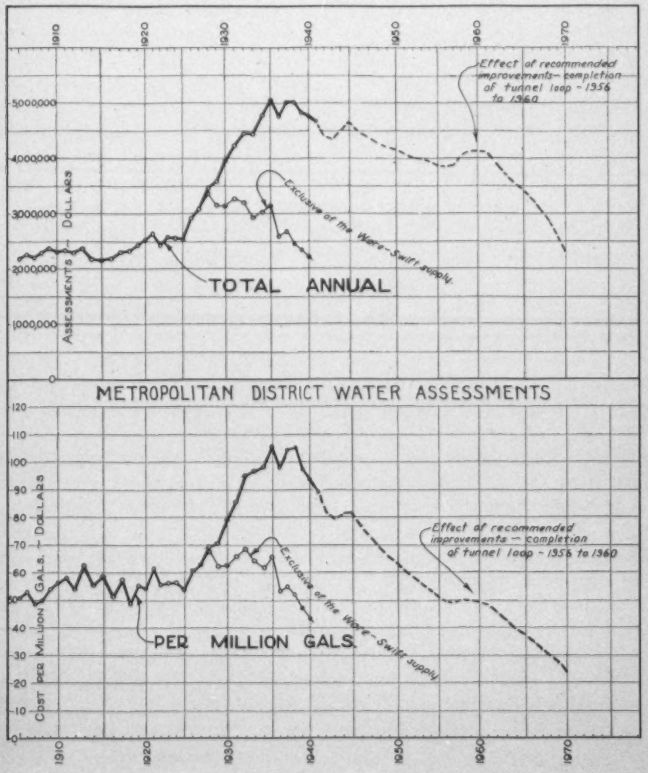

FIG. 3.

there is a rapidly increasing account, representing the debt that has been paid off, of the cost of works, which new members entering the District will not have included in their future assessments and which accordingly should be made the basis of an entrance fee representing each new member's purchase of its share of the works. Table 3 and Figure 3 show how the total assessments have varied in the past and what is to be expected in the future. This presents clearly the relation between assessments due to the old and the new supplies, but in order to interpret these details more fully, it is necessary to understand the various steps in the development of the entire supply and the methods by which they were financed.

In order to make the picture complete, it was necessary to make an assumption as to the completion of the distribution tunnel loop for distributing the supply to the centers of consumption in the District. There is no present legislative authority for this construction. However, it is a part of the recommended plan on which present developments are based. It is assumed that this additional future construction will cost nearly $20,000,000 and it is assumed that it will be undertaken in the period 1956-60, inclusive, and financed with 30-year serial bonds.

The original development consisted principally of the construction of Wachusett Dam and Reservoir in Clinton for somewhat more than $12,000,000, the construction of Wachusett Aqueduct to bring the water from Wachusett Reservoir to Sudbury Reservoir for a little over $1,800,000, the purchase from the City of Boston of the Sudbury Reservoir and Aqueduct system for about $8,700,000, the completion of the construction of Sudbury Dam and Reservoir in Southborough for a little over $2,000,000, the purchase from the City of Boston of the Cochituate Reservoir and Aqueduct system for about $1,600,000, the construction of Weston Aqueduct for a little over $2,800,000, the purchase from the City of Boston of the Chestnut Hill and Fisher Hill Distributing Reservoirs and appurtenances for about $2,650,000, the purchase from Malden, Medford and Melrose of the Spot Pond Distributing Reservoir for approximately $1,240,000, and the purchase from the City of Boston of the Mystic Works for about $1,130,000. As a part of the original development, the District also spent approximately $7,000,000 or $8,000,000 on the distribution system and other

improvements, making a total of $41,398,000 spent for what we may call the first stage of the development.

This was financed by 40-year sinking-fund bonds issued between 1895 and 1910, but mostly in the first six years of this period. The interest rates varied from 3 to 3½ per cent. Many of these bonds started to mature only recently, and now only $10,398,000 are outstanding. However, the sinking fund has been so ably administered by the State Treasurer that the net debt on account of these sinking fund bonds was only $992,195 on April 1 of this year. The Treasurer has from time to time bought back many of the District's own water bonds when conditions were right for their advantageous purchase, so that the earnings of the sinking fund are, and will continue to be, maintained at a high level, well above 3 per cent. Furthermore, there are added to the fund each year, all receipts from the sale of electric power at the Wachusett and Sudbury Dam plants and all other miscellaneous receipts of the Water District. The total of such receipts averaged during the last five years about $125,000 annually, and it is estimated that they will continue to be at least $100,000 per year. Table 4 shows the history of the financing of the original construction by sinking fund bonds and the estimated requirements for the future, which will be reduced to the vanishing point in nine years.

It is estimated that it will be unnecessary to continue after 1942 the adding to the sinking fund of the receipts from sales and other miscellaneous sources. These should be properly credited against the annual assessments of the Water District and should not, through possible lack of adequate legislation, be permitted to revert to the general funds of the state. Commencing in 1943, such credits will amount to a substantial sum, being more than doubled by the sale of electric power from new plants at Quabbin Dam and Quabbin Aqueduct. It is also estimated that it will be unnecesary to continue after this year any assessment against the District on account of sinking fund requirements other than interest on the bonds which will amount to only $303,685 next year and which will rapidly decrease to the vanishing point in the next nine years.

Following this original development which was financed by sinking fund bonds, there was a period of 15 years from 1911 to 1925 inclusive, in which additions and improvements were made from time to time principally in the distribution system. The total amount spent

TABLE 4—SINKING FUND BONDS FOR CONSTRUCTION OF OLD SUPPLY, METROPOLITAN WATER DISTRICT

	Amount of Loan	Interest Rate	Date of Maturity	Assessed Requirements Fund*	Interest	Net Debt Apr. 1
1895-7	$13,000,000	3.5	Jul. 1935	Previous to 1903 the Sinking Fund Account was not separated from interest and other accounts. Proper adjustments in the accumulated fund were made prior to that date.		
1898	4,000,000	3.5	Jan. 1938			
1899-1900	4,000,000	3.0	Jul. 1939			
1901	10,000,000	3.155	Jan. 1941			
1902	3,500,000	3.5	Jan. 1942			
1903	2,000,000	3.5	Jan. 1943	$380,745	$1,179,835	———
1904	2,000,000	3.5	Jan. 1944	397,321	1,257,548	———
1905	650,000	3.5	Jan. 1945	513,568	1,309,178	———
1906	1,350,000	3.5	Jan. 1946	520,381	1,315,750	———
1907	———	—	———	523,697	1,357,628	$35,541,052
1908	———	—	———	519,581	1,363,000	34,772,404
1909	398,000	3.25	Jan. 1949	520,331	1,369,468	34,396,663
1910	500,000	3.5	Jan. 1950	522,344	1,384,685	34,077,368
1911	———	—	———	515,369	1,393,435	33,214,109
1912	———	—	———	512,884	1,393,435	32,338,098
1913	———	—	———	506,812	1,393,435	31,452,409
1914	———	—	———	280,333	1,393,435	30,492,129
1915	———	—	———	276,734	1,393,435	29,540,061
1916	———	—	———	261,423	1,393,435	28,746,075
1917	———	—	———	260,500	1,393,435	28,002,293
1918	———	—	———	262,039	1,393,435	27,166,236
1919	———	—	———	261,966	1,393,435	26,338,269
1920	———	—	———	248,054	1,393,435	25,219,631
1921	———	—	———	234,666	1,393,435	24,136,861
1922	———	—	———	210,505	1,393,435	23,005,568
1923	———	—	———	197,493	1,393,435	21,796,240
1924	———	—	———	190,307	1,393,435	20,779,958
1925	———	—	———	179,049	1,393,435	19,670,049
1926	———	—	———	174,691	1,393,435	18,560,083
1927	———	—	———	173,355	1,393,435	17,471,103
1928	———	—	———	167,756	1,393,435	16,291,585
1929	———	—	———	155,622	1,393,435	15,005,303
1930	———	—	———	140,690	1,393,435	13,636,610
1931	———	—	———	128,831	1,393,435	12,271,233
1932	———	—	———	131,012	1,393,435	10,955,439
1933	———	—	———	130,555	1,393,435	9,616,920
1934	———	—	———	135,467	1,393,435	8,204,414

TABLE 4 (continued)

	Amount of Loan	Interest Rate	Date of Maturity	Assessed Requirements Fund*	Assessed Requirements Interest	Net Debt Apr. 1
	Paid Off					
1935	13,000,000	—	———	142,787	1,393,435	6,767,610
1936	———	—	———	118,860	938,435	5,694,377
1937	———	—	———	219,350	938,435	4,678,002
1938	4,000,000	—	———	151,301	868,435	3,522,725
1939	4,000,000	—	———	125,297	798,435	2,570,318
1940	———	—	———	79,255	678,435	1,689,878
1941	10,000,000	—	———	36,773	520,685	992,195
	To Be Paid Off				*Actual*	*Estimated*
1942	3,500,000	—	———	———	303,685	596,000
1943	2,000,000	—	———	———	205,435	320,000
1944	2,000,000	—	———	———	135,435	198,000
1945	650,000	—	———	———	89,060	125,000
1946	1,350,000	—	———	———	54,060	75,000
1947	———	—	———	———	30,435	50,000
1948	———	—	———	———	30,435	25,000
1949	398,000	—	———	———	23,968	10,000
1950	500,000	—	———	———	8,750	———

*In determining the assessment needed to meet fund requirements, receipts and earnings computed at 3% previous to the 1914 assessment, at 4% 1914-1936, inclusive, and at 3¾% beginning 1937.

on new construction in those years was $4,287,000. This was financed by serial bonds whose terms varied from 30 to 40 years, mostly the latter. The interest rates varied from 3½ to 4¼ per cent. A sum of $1,947,000 of these bonds is still outstanding, the balance having been paid off as the bonds have come due year by year. Table 5 shows the history of the financing of these additions and improvements in the old supply and distribution works by serial bonds and the requirements for the future which will be reduced to the vanishing point in 23 years.

As shown in this table, commencing in 1926, the issuing of such serial bonds was discontinued and a policy of pay as you go was adopted to care for such additions and improvements in the distribution system. The sums so spent and included directly in the assessments year by year have averaged $250,000 or more per year in recent years. This has been necessary largely because there has never been anything that could be called adequate surplus capacity in the main

TABLE 5—EXPENDITURES FOR ADDITIONS AND IMPROVEMENTS IN OLD SUPPLY AND DISTRIBUTION WORKS, METROPOLITAN WATER DISTRICT

(SUBSEQUENT TO THE ORIGINAL CONSTRUCTION BY SINKING FUND BONDS)

SERIAL BONDS 1911 TO 1925—PAY-AS-YOU-GO EXPENDITURES COMMENCING IN 1926

	Amount of Loan	Interest Rate	Date of Maturity	Premiums Credited	Assessed Requirements Principal	Interest	Net Debt Apr. 1
1911	$ 200,000	3.5	Jan. 1951	$ ———	$ 5,000	$ 3,500	$ 200,000
1912	190,000	3.5	Jan. 1951	663	10,000	12,724	385,000
1913	———	—	———	———	10,000	13,300	375,000
1914	258,000	4	Jan. 1952	13,432	17,000	21,260	623,000
1915	490,000	4	Jan. 1955	7,933	30,000	32,580	1,096,000
1916	66,000	4	Jan. 1956	2,096	32,000	42,810	1,132,000
1917	150,000	4	Jan. 1947	1,260	37,000	45,940	1,250,000
1918	———	—	———	———	37,000	47,610	1,213,000
1919	161,000	4.25	Jan. 1949	32	43,000	49,601	1,337,000
1920	34,000	4.25	Jan. 1954	———	44,000	52,188	1,328,000
1921	———	—	———	———	44,000	51,204	1,284,000
1922	500,000	4	Jan. 1962	8,105	57,000	59,476	1,740,000
1923	100,000	4	Jan. 1963	1,150	60,000	69,489	1,783,000
1924	1,000,000	4	Jan. 1964	12,680	85,000	89,181	2,723,000
1925	1,138,000	4	Jan. 1963	26,619	115,000	129,074	3,776,000
	Pay-As-You-Go						
1926	300,000	—	———	———	115,000	147,866	3,661,000
1927	355,000	—	———	———	115,000	143,299	3,546,000
1928	630,000	—	———	———	115,000	138,731	3,431,000
1929	425,000	—	———	———	115,000	134,164	3,316,000
1930	425,000	—	———	———	114,000	129,596	3,201,000
1931	690,297	—	———	———	114,000	125,050	3,087,000
1932	496,700	—	———	———	114,000	120,525	2,973,000
1933	354,000	—	———	———	114,000	116,000	2,859,000
1934	407,459	—	———	———	114,000	111,475	2,745,000
1935	450,000	—	———	———	114,000	106,950	2,631,000

TABLE 5 (continued)

	Amount of Loan	Interest Rate	Date of Maturity	Premiums Credited	Assessed Requirements: Principal	Assessed Requirements: Interest	Net Debt Apr. 1
1936	399,000	—	———	———	114,000	102,425	2,517,000
1937	317,903	—	———	———	114,000	97,900	2,403,000
1938	250,000	—	———	———	114,000	93,375	2,289,000
1939	250,000	—	———	———	114,000	88,850	2,175,000
1940	250,000	—	———	———	114,000	84,325	2,061,000
1941	280,000				114,000	79,800	1,947,000
	Estimated				*Actual*	*Actual*	*Actual*
1942	200,000	—	———	———	112,000	75,275	1,833,000
1943	200,000	—	———	———	111,000	70,790	1,721,000
1944	150,000	—	———	———	111,000	66,365	1,610,000
1945	100,000	—	———	———	108,000	61,960	1,499,000
1946	50,000	—	———	———	107,000	57,615	1,391,000
1947	50,000	—	———	———	102,000	53,348	1,284,000
1948	Continuing	—	———	———	100,000	49,197	1,182,000
1949	about	—	———	———	95,000	45,188	1,082,000
1950	50,000	—	———	———	95,000	41,323	987,000
	per						
1951	year	—	———	———	86,000	37,567	892,000
1952		—	———	———	81,000	33,966	806,000
1953		—	———	———	81,000	30,624	725,000
1954		—	———	———	80,000	27,381	644,000
1955		—	———	———	70,000	24,160	564,000
1956		—	———	———	69,000	21,160	494,000
1957		—	———	———	69,000	18,380	425,000
1958		—	———	———	69,000	15,620	356,000
1959		—	———	———	69,000	12,860	287,000
1960		—	———	———	69,000	10,100	218,000
1961		—	———	———	68,000	7,340	149,000
1962		—	———	———	56,000	4,600	81,000
1963		—	———	———	25,000	2,120	25,000
1964		—	———	———	———	500	———

supply lines, and because it has been necessary continually to bury more mains in the already crowded streets within the District proper. This situation is discussed at length in the report of the Joint Board, previously referred to as House Document 262 of 1938, and is one of the reasons which led to the recent construction of the new pressure aqueduct and the proposal to extend it in a deep rock tunnel to the heart of the District at Chestnut Hill. Under this plan, it will then be unnecessary to continue these large annual expenditures for substantial additions to the supply mains; and it is estimated that in about 5 years they can be reduced to something like $50,000 per year.

The extension of the sources of supply to the Ware and Swift rivers was commenced in 1926 as a result of legislation in Chapter 375 of the Acts of that year, later supplemented by Chapter 321 of the Acts of 1927, and is practically completed at the present time. A special commission, the Metropolitan District Water Supply Commission, was created to do the work, and the sum of $65,000,000 was appropriated therefor. The situation with respect to the supply was so critical at that time that this Commission was also given by an appropriation of $900,000 to do certain work of rehabilitation in the Southern Sudbury area. This was completed within a year at a cost of $638,534, and the balance of the appropriation reverted.

For reasons already explained, the new supply was developed in several stages. First, the east half of Quabbin Aqueduct Tunnel was driven to Coldbrook on the Ware River and the Ware supply obtained in 1931 at a cost, which, together with estimated commitments, now totals about $15,200,000. Next, the aqueduct was extended to tap the Swift River in 1934, at a cost of approximately $5,400,000. Next, Quabbin Reservoir was completed including construction of Winsor Dam and Quabbin Dike which were completed ready to start filling the reservoir in 1939 at a cost, which together with estimated commitments, now totals nearly $30,000,000.

This left a considerable unexpended balance from the original appropriation, which the Legislature then matched with a federal grant of approximately $7,000,000 for the purpose of constructing the new pressure aqueduct, which has just been completed. The work under federal grant included a number of additions and improvements in both the Ware and Swift areas, the construction of a new high-level distributing reservoir in Weston, Norumbega Reservoir, the enlarge-

ment of the high-level reservoir in Middlesex Fells, and certain improvements in the old Wachusett-Sudbury system, such as additional pipe lines in the Weston Aqueduct siphons, waterproofing the Assabet Bridge on the Wachusett Aqueduct, by-passing Spot Pond, etc.

Altogether, the actual and estimated capital expenditures by the special Metropolitan District Water Supply Commission will total nearly $74,000,000, of which $64,235,000 has been or will be spent from District funds for the new supply and the pressure aqueduct. Table 6 shows the details of these expenditures and the extent to which contributions have been obtained under the federal grant. All these expenditures were financed by 30-year serial bonds, except that the work was started with $1,000,000, received in 1926 from the city of Worcester for the right to divert from an additional 20.7 sq. miles of the Wachusett drainage area, and except that the first bond issue of $1,000,000 in 1927 was for a period of 20 years instead of 30 years. The interest rates have varied from 1¾ to 4¼ per cent, loans in the last two years having been obtained at the lower figure. A sum of $44,757,000 of these bonds is now outstanding. Table 7 shows the history of the financing of this recent construction by serial bonds and the estimated requirements for the future, which will continue for the next 34 years.

One important consideration in estimating the future growth of the District is the matter of enlargement by the addition of new municipalities and the question of proper entrance fees to be charged. There are 15 non-member municipalities within ten miles of the State House which are, on that account, entitled to membership in the Water District under existing legislation. Only a few of these have supplies, the safe yield of which is more than adequate for reasonable future needs, and the quality of which can probably be satisfactorily maintained. A larger number have supplies which appear to be adequate for present needs, but which can be satisfactorily maintained for a limited period only, both with respect to quantity and quality. Some of these are in the watershed of the Charles River and are subject to present and also, undoubtedly, to future legislative limitations. Table 8 summarizes the trend of the total demand on District sources and includes an estimate of the future demand, not only by the present membership of the District but by other municipalities. It is believed that this estimate, particularly of the additional demand due to new

TABLE 6—ACTUAL (AND ESTIMATED) CAPITAL EXPENDITURES BY THE METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

	In Connection with the Old Supply			For the New Supply and Pressure Aqueduct		
	Federal Contribution under P.W.A. Grant	From District's Bond Issues	Dept. of Pub. Wks. Contribution to Highway Cost	Federal Contribution under P.W.A. Grant	From District's Bond Issues	Total
So. Sudbury Supply	———	$638,534	———	———	———	$ 638,534
Ware Supply & Wachusett-Coldbrook Section of Quabbin Aqueduct	———	———	———	$ 44,000	$14,693,000	14,737,000
(Future Power Plant and Watershed Protection)	———	———	———	———	(555,000)	(555,000)
Coldbrook-Swift Section of Quabbin Aqueduct	———	———	———	800	5,400,500	5,401,300
Quabbin Reservoir	———	———	$582,047	884,000	19,159,794	20,625,841
(Future Power Plant, Real Estate & Diversion Damage Settlements, Watershed Protection & Reforestation)	———	———	———	———	(3,000,000)	(3,000,000)
Winsor Dam	———	———	———	19,300	5,825,000	5,844,300
Quabbin Dike	———	———	———	———	2,886,000	2,886,000
Investigation of Lake Cochituate	———	12,513	———	———	———	12,513
Protection of Wachusett Watershed	———	153,028	———	———	———	153,028
(Future Works)	———	(220,000)	———	———	———	(220,000)

TABLE 6 (continued)

	In Connection with the Old Supply			For the New Supply and Pressure Aqueduct		
	Federal Contribution under P.W.A. Grant	From District's Bond Issues	Dept. of Pub. Wks. Contribution to Highway Cost	Federal Contribution under P.W.A. Grant	From District's Bond Issues	Total
Pressure Aqueduct, Wachusett to Norumbega Reservoir	———	———	———	4,300,000	5,725,000	10,025,000
(Future Real Estate Settlements, etc.)	———	———	———	(86,500)	(115,000)	(201,500)
Norumbega Reservoir & Pressure Distribution Aqueduct East	———	———	———	1,200,000	1,850,000	3,050,000
(Future Real Estate Settlements & City Tunnel)	———	———	———	(35,000)	(6,045,000)	(6,800,000)
Weston Aqueduct Siphons	$144,200	191,677	———	———	———	335,877
Spot Pond By-Pass	72,200	95,523	———	———	———	167,723
Enlarged Fells Reservoir	———	———	———	12,800	16,990	29,790
Assabet Bridge	2,900	3,725	———	———	———	6,625
	$219,300	$1,315,000	$582,047	$6,582,400	$65,271,284	$73,970,031
Received from Worcester		— 1,000,000		Rents, sales, etc.	— 1,036,284	
Total from District Funds		$ 315,000			$64,235,000	

TABLE 7—SERIAL BONDS FOR NEW WARE-SWIFT SUPPLY, PRESSURE AQUEDUCT, ETC., METROPOLITAN WATER DISTRICT

	Amount of Loan	Interest Rate	Date of Maturity	Assessed Requirements: Premiums Credited	Principal	Interest	Net Debt Apr. 1
1927	$1,000,000	3.5 & 4	Jan. 1947	———	———	———	———
1928	4,000,000	4	July 1958	$18,000	$ 50,000	$ 21,580	$ 950,000
1929	4,000,000	4	Jan. 1959	41,440	185,000	198,959	8,900,000
	2,000,000	4.25	July 1959	———	———	———	———
1930	3,500,000	4	Jan. 1960	50,860	390,000	455,372	14,080,000
	1,000,000	3.5 & 4	July 1960	———	———	———	———
1931	2,000,000	3.5	Jan. 1961	45,082	544,000	588,169	16,570,000
1932	2,000,000	3.5 to 4.25	Jan. 1962	18,162	614,000	652,655	15,956,000
	3,000,000	3.5	July 1962	———	———	———	———
1933	3,000,000	3.25	Jan. 1963	68,400	784,000	796,267	20,272,000
1934	3,000,000	3.25	Jan. 1964	24,330	884,000	898,908	25,388,000
1935	2,250,000	2.5	Jan. 1965	21,300	984,000	945,422	26,654,000
	3,500,000	2.5	July 1965	———	———	———	———
1936	5,000,000	2.25	July 1966	55,952	1,176,000	1,029,250	29,095,000
1937	3,000,000	2.25	July 1967	37,495	1,343,000	1,099,840	32,919,000
1938	5,000,000	2	July 1968	8,250	1,443,000	1,121,673	34,576,000
1939	5,000,000	2	Jan. 1969	82,950	1,443,000	1,148,755	38,133,000
1940	3,000,000	1.75	July 1969	91,697	1,438,000	1,251,942	44,690,000
1941	1,500,000	1.75	July 1970	41,548	1,432,000	———	44,757,000
Estimated							
1942	4,000,000	2	Jan. 1972	40,000	1,427,000	1,249,605	47,000,000
1943	2,000,000	2.25	Jan. 1973	20,000	1,557,000	1,263,529	47,773,000
1944	1,000,000	2.5	Jan. 1974	10,000	1,827,000	1,247,876	47,146,000
1945	800,000	2.75	Jan. 1975	800	2,181,000	1,213,512	45,885,000
1946	———	—	———	———	2,268,000	1,161,749	43,677,000
1947	———	—	———	———	2,268,000	1,097,733	41,409,000

TABLE 7 (continued)

	Amount of Loan	Interest Rate	Date of Maturity	Premiums Credited	Assessed Requirements Principal	Assessed Requirements Interest	Net Debt Apr. 1
1948	——	—	——	——	2,218,000	1,034,715	39,191,000
1949	——	—	——	——	2,213,000	972,698	36,973,000
1950	——	—	——	——	2,208,000	910,979	34,765,000
1951	——	—	——	——	2,208,000	849,363	32,557,000
1952	——	—	——	——	2,208,000	787,745	30,349,000
1953	——	—	——	——	2,208,000	726,128	28,141,000
1954	——	—	——	——	2,203,000	664,566	25,938,000
1955	——	—	——	——	2,202,000	603,074	23,736,000
1956	——	—	——	——	2,201,000	541,594	21,534,000
1957	——	—	——	——	2,200,000	480,139	19,333,000
1958	——	—	——	——	2,200,000	418,705	17,133,000
1959	——	—	——	——	2,070,000	357,274	14,933,000
1960	——	—	——	——	1,875,000	303,640	12,993,000
1961	——	—	——	——	1,727,000	257,671	11,233,000
1962	——	—	——	——	1,662,000	216,455	9,571,000
1963	——	—	——	——	1,492,000	177,728	7,979,000
1964	——	—	——	——	1,392,000	145,312	6,587,000
1965	——	—	——	——	1,292,000	116,148	5,295,000
1966	——	—	——	——	1,100,000	89,558	4,079,000
1967	——	—	——	——	934,000	66,822	2,979,000
1968	——	—	——	——	834,000	47,818	2,045,000
1969	——	—	——	——	634,000	31,067	1,211,000
1970	——	—	——	——	314,000	20,313	777,000
						Paid off in 1975	

TABLE 8—GROWTH OF POPULATION IN THE METROPOLITAN WATER DISTRICT AND WATER CONSUMPTION IN MILLION GALLONS DAILY

	20 Cities and Towns Now Members of Metropolitan Water District								
	Population	Gallons Per Capita Daily (and Per Cent of Services Metered)	Total Consumed —m.g.d.	Credit from Local Sources, Newton and Brookline —m.g.d	Supplied to Near-by Cities and Towns which may join the District from time to time —m.g.d	Total Supplied to Members —m.g.d.	Supplied to Non-Members such as Framingham, Natick, hospitals, etc. —m.g.d.	Supplied to Worcester by Pumping from Wachusett Area —m.g.d	Total Demand on District Sources —m.g.d.
1850	226,540	——	——	——	—	——	——	——	——
1860	321,189	——	——	——	—	——	——	——	——
1870	389,625	——	——	——	—	——	——	——	——
1880	508,884	——	——	——	—	——	——	——	——
1885	565,521	——	——	——	—	——	——	——	——
1890	674,535	——	——	——	—	——	——	——	——
1895	779,581	90.6	70.82	——	—	——	——	——	——
1900	897,475	111.4 (8)	100.00	——	—	——	——	——	——
1905	974,877	125.3 (11)	122.13	— 6.05	—	116.08	1.88	——	117.96
1910	1,098,048	107.6 (38)	118.22	— 6.13	—	112.09	0.87	——	112.96
1915	1,234,790	87.1 (67)	107.52	— 5.58	—	101.94	1.06	0.13	103.13
1920	1,290,651	104.1 (74)	134.40	— 7.13	—	127.27	1.38	——	128.65
1925	1,398,702	97.6 (96)	136.52	— 7.66	—	128.86	3.06	2.58	134.50
1930	1,498,253	97.5 (99)	146.11	— 8.95	—	137.16	3.56	2.39	143.11
1935	1,548,282	90.9(100)	140.71	— 9.45	—	131.26	3.89	——	135.15
1940	1,509,376	98.8(100)	149.16	— 9.68	—	139.48	4.03	——	143.51
Estimated									
1945	1,600,000	102	163	—10	3	156	4	2	162
1950	1,700,000	104	177	—10	11	178	5	5	188
1955	1,800,000	106	191	— 5	20	206	5	8	219
1960	1,900,000	108	205	— 5	30	230	6	10	246
1965	1,950,000	110	215	——	37	252	6	10	268
1970	2,000,000	112	224	——	40	264	7	10	281

membership in the District, is conservative. It assumes that such increase will be only 20 m.g.d. in 1955 and only 40 m.g.d. in 1970.

It is possible to take almost any position as to the amount of entrance fee that should be charged any municipality. The author is not one of those who believes that since the non-members have neglected the opportunity to join in the past, they should be charged a sum intended to offset any alleged delinquency of theirs, nor one of those who consider the District's surplus water as a drug on the market to be disposed of at bargain prices. There has never been any obligation, legal or otherwise, upon any of the non-members to join the District. They have simply elected to maintain their own local supplies or develop new ones. Such communities, although contributing nothing to the cost of the District's supply, have had their own costs in connection with their own supplies, and should not be penalized for electing the one in preference to the other.

One of the principal things to consider is that the safe yield of the Wachusett-Sudbury supply is exceeded by the demand of the present membership and that if no new supply had been available no other towns could be admitted. Hence, from now on, all new members should be considered as joining for the purpose of sharing the new supply only, its benefits and also its cost. It is true, of course, that some of the bonds issued to defray the cost of what we call the old supply were for distribution works which are used in connection with the new as well as the old supply, and that in recent years many direct expenditures have been incurred for such distribution works. Nevertheless, it is also true that the District can well afford to take a liberal attitude in the matter of entrance fees and adopt a simple criterion not complicated by a consideration of the precise use or extent of depreciation of the separate parts of the work.

Regardless of the criterion adopted as the basis for entrance fees, the chronological sequence in which various towns may enter is of considerable importance, and the town which enters first alone would pay a higher fee than if it entered together with others, although this disadvantage would be offset by the benefit it would receive from the fees of other subsequent entrants. Nevertheless, if it is conceded that the purpose of admitting towns is to have them share the new supply just developed, then it would seem to be an appropriate time to fix an entrance fee basis applicable to all eligible municipalities regardless of

their intentions as to joining. By such a plan not only would each eligible member understand exactly what to expect, but no financial disadvantage would be attached to the mere fact of being the first in line.

It should be understood that the author does not speak for the Metropolitan District Commission and is only interested in presenting the facts that bear upon this situation and in arousing a proper and more widespread interest in them than now exists. Two points of view should be weighed against each other, requiring two questions to be answered: First, what is the share of each eligible municipality in the investment in the new works represented by cash already paid by the existing members of the District? Second, what will be the financial advantage now and in the future, to the existing members, of such enlargement?

To answer the first question, note that Table 6 shows that the bonds issued by the Metropolitan District Water Supply Commission for constructing the new supply and pressure aqueduct are expected to amount to $64,235,000, upon the completion of the distribution tunnel to Chestnut Hill, which will make it possible to discontinue the present pumping at that point to the Southern High Service. This is the major part of the Commission's estimated total expenditure of about $73,970,000, the balance representing the expenditure of Federal funds contributed under P.W.A. grant and expenditures in connection with the old supply, etc. Table 9 shows the extent to which the present membership has and will be assessed to pay for this investment. It also shows the additional amounts which will probably be assessed in the future to pay for the extension of the distribution tunnel in the form of a loop beneath the centers of distribution, which will eliminate also the present pumping at Spot Pond to the Northern High Service. It also shows a considerable debt still outstanding on account of the cost of the old works which were financed by bonds with terms up to 40 years and hence still unpaid. Since this debt must in any event, under the established method of making assessments, be fully shared by all members, new and old, it must be deducted if we are to base entrance fees upon the criterion of sharing the new works only. The table indicates what such a basis for entrance fees would be now and in each subsequent year and shows that if such a basis were maintained without any more lenient adjustments in the future, the

TABLE 9.—ESTIMATED ANNUAL INCREASE IN ENTRANCE FEES BASED ON SHARING NEW WORKS ONLY, METROPOLITAN WATER DISTRICT

	Total Assessments to Date, to Pay Off Serial Bonds for New Supply and Pressure Aqueduct (after deducting $315,000 net present and future cost in connection with the old works)	Probable Additional Total to Date to Pay for Future Tunnel Loop	Net Water Debt Remaining on April 1 of the Following Year, on Account of Cost of the Old Works	Total Assessments to Date for New Supply Less Unpaid Balance on Old Works	Entrance Fee of Any Municipality in Subsequent Years in Per Cent of Fee for Entrance in 1941 (in time to share assessment of 1942)
1941	$12,395,000	———	$2,429,000	$ 9,966,000	100
1942	13,822,000	———	2,041,000	11,781,000	118
1943	15,379,000	———	1,808,000	13,571,000	136
1944	17,206,000	———	1,624,000	15,582,000	156
1945	19,387,000	———	1,466,000	17,921,000	180
1946	21,655,000	———	1,334,000	20,321,000	204
1947	23,923,000	———	1,207,000	22,716,000	228
1948	26,141,000	———	1,092,000	25,049,000	251
1949	28,354,000	———	987,000	27,367,000	274
1950	30,562,000	———	892,000	29,670,000	298
1951	32,770,000	———	806,000	31,964,000	320
1952	34,978,000	———	725,000	34,253,000	344
1953	37,186,000	———	644,000	36,542,000	366
1954	39,389,000	———	564,000	38,825,000	389
1955	41,591,000	———	494,000	41,097,000	412
1956	43,792,000	———	425,000	43,367,000	435
1957	45,992,000	$ 130,000	356,000	45,766,000	459
1958	48,192,000	390,000	287,000	48,295,000	484
1959	50,262,000	780,000	218,000	50,824,000	510
1960	52,137,000	1,300,000	149,000	53,288,000	535
1961	53,864,000	1,950,000	81,000	55,733,000	559
1962	55,526,000	2,600,000	25,000	58,101,000	583
1963	57,018,000	3,250,000	———	60,268,000	605
1964	58,410,000	3,900,000	———	62,310,000	625
1965	59,702,000	4,550,000	———	64,252,000	645
1966	60,802,000	5,200,000	———	66,002,000	662
1967	61,736,000	5,850,000	———	67,586,000	677
1968	62,570,000	6,500,000	———	69,070,000	692
1969	63,204,000	7,150,000	———	70,354,000	705
1970	63,518,000	7,800,000	———	71,318,000	715
	Ultimately $64,235,000 in 1975	Ultimately $19,500,000 in 1990			

entrance fee of any municipality may be expected to be about doubled by a delay of five years, tripled in nine years, and quadrupled in thirteen or fourteen years. This statement is liable to mislead the reader into thinking that a town entering five years from now, for example, would bear a much heavier share of the financial burden. Actually this would not be the case since a town entering now would, during the next five years, bear the burden of increasing assessments on account of the cost of the new works, and also unavoidable assessments on account of the old works, and the later entrant does not suffer in the comparison.

To answer the second question, as well as the first, Table 10

TABLE 10—PERCENTAGE SHARE OF NEW MEMBERS IF ALL ELIGIBLE MUNICIPALITIES SHOULD JOIN THE WATER DISTRICT

	Consumption in 1940 —m.g.d.	Total Value of Assessed Estate Dec. 1940, Pub. Document 19, Part II	Approximate Percentage Based 2/3 on Consumption and 1/3 on Valuation	Same if the Consumption of Entrants is Taken as Nothing
20 Municipalities in the District at present (incl. 1/5 Valuation and no Consumption for Newton)	144.032 (credit for 4.578 from local source in Brookline)	$2,542,236,526	79.8	93.0
Braintree	1.426	25,326,050	0.82	0.27
Cambridge	12.272	170,603,600	6.53	1.83
Canton	0.672	8,099,010	0.34	0.09
Dedham	1.104	24,739,800	0.69	0.27
Hingham	0.608	16,235,025	0.41	0.17
Hull	0.650	17,395,400	0.44	0.19
Lynn	7.729	130,825,320	4.37	1.41
Needham	0.739	25,284,010	0.55	0.27
Saugus	0.665	15,911,113	0.43	0.17
Wakefield	0.762	20,757,660	0.52	0.22
Waltham	2.721	50,166,850	1.58	0.54
Wellesley	1.341	43,641,600	0.98	0.47
Weymouth	1.312	49,186,047	1.03	0.53
Winchester	1.000	32,728,900	0.73	0.35
Woburn	1.504	20,406,860	0.78	0.22
	178.537	$3,193,543,771	100.00	100.00

shows the share of each of the fifteen eligible municipalities based on the established method of apportioning two-thirds on the basis of the previous year's consumption and one-third on the basis of the previous year's valuation. The latest figures for consumption and valuation, namely those for the year 1940, should be adequate for this purpose and are used in the table. In other words, the resulting percentages represent the actual condition that would have obtained if the new alignment of membership had been in effect for the assessment of the present year, 1941. Shares based two-thirds on consumption and one-third on valuation are those which will be in effect under existing legislation after the town in question joins the District and starts to use the supply. However, it does not appear to be too liberal a basis for determining entrance fees to give the town credit for the fact that it has not yet actually used any of the water, and that if it joined merely to insure its future by sharing the new works and continued to use its own local supply, as it would have every right to do, then its consumption would be counted as nothing in the computation of shares. In fact, one member of the District, the City of Newton, has for many years done this very thing.

The last column in the table shows what the result would be if the consumption of all the entrants is taken as nothing in the computation of shares. These percentages applied to the suggested entrance fee base of approximately $10,000,000 give the fee which each entrant in 1941 would have to pay, in addition to the cost of the physical connection, if it were required, as suggested, to share the cost of the new works only. For example, the smallest town, Canton, and the largest, Cambridge, would pay now on the most liberal basis, as suggested, entrance fees respectively of about $9,000 and $183,000, and thereafter, if they completely abandoned their local supplies and took water from the District, would pay respectively 0.34 and 6.53 per cent of the total District assessment, which, as the chart indicates, will average about $80 per million gallons during the next five years, dropping to about $60 in another five years and to about $50 in still another five years. However, any new member that continued to use its own local supply would receive a credit in proportion to the extent of such use. The table also indicates the extent to which the present membership will benefit. If all the eligible municipalities should join, the effect would be to reduce the individual assessments by about 20 per cent.

Although there is no obligation on any municipality to join the District, or share with it in any way, nevertheless it is obvious that every city and town within its reach actually does share the protection that the District's supply insures. This is especially true of towns that rely on the false security which extended periods of ample rainfall give them, oblivious of the certainty that occasional droughts, even though they may come only once in ten years, bring them to the door of the District asking for water because their local sources cannot be adequately maintained through drought as well as flood. It is true that the District itself is vulnerable on account of the possibility of local failures in the Distribution system and that it may in turn have to call upon its neighbors. However, such a local situation is entirely reciprocal, the temporary assistance being on one side as much as on the other, and does not affect the broader consideration that the District has developed a supply of unquestioned adequacy and permanence which in the last analysis is insurance for non-members as well as for members. It is only fair that the non-members who are really affected in a substantial way should pay a premium for this insurance.

The author believes that it would be fair to have some impartial body, like the Department of Public Health, periodically take account of stock to determine the adequacy, both from the standpoint of quality and safe yield in quantity, of the supply of all towns eligible for membership by reason of their location; and to assess insurance premiums where applicable at an annual rate of something like 0.03 per cent of the town's valuation. Apparently, it would be necessary, in the last analysis, for the Supreme Judicial Court to have the determining voice. Such assessed premiums should fairly be allowed to accumulate as a credit against the entrance fee at such time as the town elected to join the District.

The author also believes that it would be reasonable to permit the payment of entrance fees and costs of connection to be spread over a number of years, particularly since in some instances the costs of connection may run into considerable sums.

Any discussion of this general subject would not be complete without a statement, to supplement these figures as to wholesale rates, of the rates actually charged the consumer in the various towns in the District. Table 11 shows in the case of each member municipality the rates charged at both ends of the scale, on the one hand the small con-

TABLE 11—RATES FOR METERED WATER IN THE METROPOLITAN WATER DISTRICT

	Minimum Rates	Corresponding quantity and rate		Minimum rate at end of sliding scale	
		Cu. Ft.	Per 100 Cu. Ft.	In excess of (Cu. Ft.)	Per 100 Cu. Ft.
Arlington	$ 2.50 quarterly	1,087	$0.23	250,000 quarterly	$0.15
Belmont	2.50 quarterly	750	0.333	750 quarterly	0.20
Boston	10.00 annually	5,435	0.184	1,000,000 quarterly	0.105
Brookline	———	——	0.18	———	0.18
Chelsea	1.50 quarterly	1,153	0.13	———	0.13
Everett	6.00 annually	4,000	0.15	1,000,000 quarterly	0.12
Lexington	3.75 quarterly	1,250	0.30	50,000 quarterly	0.18
Malden	2.50 quarterly	1,316	0.190	500,000 annually	0.15
Medford	2.00 quarterly	1,000	0.20	120,000 monthly	0.12
Melrose	9.00 annually	4,500	0.20	15,000 annually	0.15
Milton	1.80 quarterly	655	0.275	1,000 quarterly	0.25
Nahant	10.00 annually	5,340	0.187	———	0.187
Newton	2.25 quarterly	1,250	0.18	90,000 quarterly	0.12
Quincy	9.50 semi-annually	3,600	0.264	3,600 semi-annually	0.18
Revere	10.00 annually	6,670	0.15	———	0.15
Somerville	1.50 quarterly	900	0.167	600,000 monthly	0.10
Stoneham	8.00 annually	3,200	0.25	700,000 annually	0.13
Swampscott	8.00 annually	3,500	0.229	50,000 annually	0.15
Watertown	10.00 annually	4,000	0.25	2,920,000 annually	0.16
Winthrop	10.00 annually	6,667	0.15	———	0.15

sumer paying only the minimum rate, and on the other hand the large consumer using enough to secure the lowest rate per hundred cubic feet. These figures were obtained from the Water Division of the Metropolitan District Commission.

The city which is most interested in this entire subject is, of course, Boston since its share of all expenses and all benefits is twice that of all the other nineteen cities and towns in the District put together. For example, last year it paid $3,110,209 out of a total assessment of $4,785,945. This is due merely to the relative size of Boston and not, as has sometimes been critically stated, to any unfairness in the method of apportioning the assessments. In fact, if the shares were based solely on actual quantity of water consumed, omitting all consideration of valuations, then Boston would pay approximately $100,000 more per year.

Discussion

Henry F. Beal.[1] The city of Waltham has a municipally owned water works plant, dating back to 1872. The supply comes from two large collecting wells near the northerly bank of the Charles River. The well and pumping plant at Station No. 1 are situated within a hundred feet of the river and mostly on made land. The well and pumping plant at Station No. 2 are situated several hundred feet from the river and about four-fifths mile up stream from Station No. 1. Water in this well stands some four or five feet above normal river level. Water in well No. 2 has a temperature of 51° F., is practically iron free, and causes no trouble. Unfortunately the quantity of water obtainable from this well is limited to about 1 m.g.d. With an average consumption of nearly 3 m.g.d., it is thus necessary to draw approximately 2 m.g.d. from the older well at Station No. 1, the iron content of which is excessive and a continual source of annoyance and expense. The mixed water in the system has far too much iron and causes expense and trouble to the department and the consumer.

Surveys and studies have been made by the Water Department and its consulting engineers for the installation of a system of gravel-packed wells in the reservation up stream from Well No. 1. Water, practically iron-free, has been found, and a supply of 3 m.g. in a 12-hour period could be obtained and conducted to Station No. 1, leaving the old well in commission in case of emergency. The expense of this installation is estimated at approximately $120,000. The other solution is entrance into the Metropolitan System, a matter which needs careful study. To that end the writer has made the following recommendation under date of November 1, 1940.

Hon. Arthur A. Hanson
Mayor of Waltham

Re: Waltham Water Supply

My dear Mr. Mayor:

I respectfully submit the following supplementary report relative to the matter of the Waltham Water supply.

The Metropolitan Water Works has recently completed and opened the Quabbin Aqueduct and the new high level reservoir in Weston. This makes Metropolitan water available in the City of Waltham at an elevation of approximately 17 feet higher than the overflow level of our main reservoir.

[1]City Engineer and Director of Public Works, Waltham, Mass.

I feel that now is the time that we should make a careful study as to the advisibility of entering the Metropolitan system. The engineering phase of the matter is relatively simple, and the problem is largely one of finance. I feel that the study should be carried out by a special commission appointed for the purpose. I respectfully suggest a commission of five members to be known as the Water Supply Commission, and I further suggest that two members be chosen from the City Council, two from Waltham citizens who are experienced in matters of finance and industry, and the fifth member to be the City Engineer and Director of Public Works.

Very truly yours,

HENRY F. BEAL,
City Engineer and Director

DANIEL M. SULLIVAN.[2] Mr. Kennison's paper is thorough and complete, and gives a very clear idea of how a large water system is developed without too severe a charge being placed upon the water takers. It also brings out clearly the careful planning and long-range viewpoint of the development of the system in anticipating both the growth of the cities and towns and the needed supply of water. As Mr. Kennison so nicely puts it, Boston is the city in the Metropolitan District most vitally interested in this subject.

The Act of the Legislature that created the Metropolitan District Commission in their wisdom stated that the cost of the system shall be borne by all the members of the system, and the cost shall be assessed based on two factors: valuation of the community and consumption of water. Boston having been in the past the wealthiest city in the area has paid the major portion of the costs of the development and maintenance of the Metropolitan System.

In 1940, Boston paid $3,110,208.64 out of a total of $4,951,678.43, or 62.8% and consumed approximately 64.8% of all water used in the Metropolitan System. In 1930, Boston paid $2,679,165.32 out of a total of $4,081,517.64, or 65.6% and consumed approximately 66.2% of all water used in the Metropolitan System. As we go back to 1910, we find Boston paying $1,815,658.85 out of a total of $2,297,787.77, or 78.2% while it used approximately 78.9% of all water consumed in the Metropolitan System. These figures clearly demonstrate that the city of Boston is paying the major portion of the cost of the water furnished by the Metropolitan District Commission to the various cities and towns in the District.

[2]Director of Water Division, Department of Public Works, Boston, Mass.

With the development of the Swift and Ware River Water Supply, the Metropolitan Area has sufficient water on hand to take care of the needs of all municipalities now members of the system; in fact, there is sufficient water to take care of additional communities within the area and outside the area if legislation is enacted to allow them to join the Metropolitan System. The question has been debated *pro* and *con* to give these municipalities an inducement in the form of a low entrance fee to join the system.

It is my personal opinion that the suggestion of Mr. Kennison that the District could take a liberal attitude in the matter of entrance fees, is a good one, although I also believe that at the time entrance fees are discussed the city of Boston should be a party to the discussion.

In the past, the Metropolitan District has taken a very liberal attitude towards the towns within the Metropolitan Area who have not joined the system. Standby connections have been made so that a city or town may be riding on a system which barely meets its needs. The community would face a shortage of water in the event of a drought, but with Metropolitan System in a position to supply water, the community would be in no hurry to develop an additional system of its own, or take the other alternative of joining with the Metropolitan System. I believe personally that a rather severe standby charge should be assessed in order to induce these municipalities to join the Metropolitan System.

Every new customer taken into the system lightens the financial burdens of the members already in the Metropolitan System. The cooperation between the Water Division of the Metropolitan District Commission and the cities and towns in the area has been excellent, and a very cordial feeling exists. The plan developed by the Legislature has worked to the advantage of all the municipalities throughout the area in providing a good and adequate supply of water.

HOWARD M. TURNER.[3] This is a most interesting and comprehensive paper. It is particularly interesting on the discussion of the charges to the communities which have not yet joined the District. It is this that I wish to discuss. Mr. Kennison is to be congratulated for his approach to this admittedly difficult problem. This question is, after all, an engineering and economic problem which should be ap-

[3]Consulting Engineer, Boston, Mass.

proached from that point of view. The plan outlined by Mr. Kennison starts down the road of approach to it on this basis. Seven years ago when I was a member of the Cambridge Water Board (I am not now a member so do not speak, of course, for the Board) I read a paper before this Society on the 1931 additions to the Cambridge water supply. This contained the following statement:

> The Joint Report of the Metropolitan Water Supply made in 1922 lists 16 cities and towns within the 10 mile radius which were not members but might be expected to join in the use of the new Ware and Swift river supplies. As far as I know none of them has yet come in. Like Cambridge many of these may not be able to afford to enter the Metropolitan System under the present methods of charging for water.

So far as I know there has been no change in this period and none of the towns and cities have entered the District. The problem has been approached before this entirely from the Metropolitan point of view, without, it seems, adequate appreciation of the fact that a municipality which has paid for its own supply and is satisfied with it is not going to pay a lot of money to give it up. In this paper the matter is approached in a rational manner and it is hoped that future negotiations which are bound to come up when some of the present water supplies get to be inadequate will be conducted more along the lines he suggests than has been done in the past.

First, considering the initial fee, Mr. Kennison proposes an arrangement by which this entrance fee to be assessed to incoming municipalities is to take into account whether they are going to use any water and would also be figured only on the more recent developments of the Metropolitan. It is interesting to compare this proposal with the former system. In the paper previously referred to on Cambridge water supply, I stated that Cambridge could not afford to go into the Metropolitan but had instead developed its own supply to the full because the entrance charge quoted in 1930 was $2,620,000. At that time, if Cambridge had gone into the Metropolitan it would only have used very little water, such a small amount as to be negligible. According to Mr. Kennison's proposal, this entrance fee would now be $183,000 instead of $2,620,000. This is getting down towards the point where a city like Cambridge might consider entering for the sake of insurance on its own requirements for future water. It is too bad that Mr. Kennison has found it necessary to increase this entrance fee so

rapidly as he proposes. To raise the fee by three times in ten years and seven times in twenty years is certainly compounding with a vengeance. This savors a little bit of the old system on which the entrance fee appeared to be figured on a penalty basis. It would be better if some other more equitable method could be worked out for these entrance charges.

As a matter of fact the question of entering the Metropolitan systems comes at certain definite periods, before a community that is not now in the District. In Cambridge, for example, there was the time in 1919 when it had to do something about the quality of the water and built a filter plant instead of paying $1,134,000, the entrance fee at that time. Once the filter plant was built and the supply was adequate, the question of entering the Metropolitan naturally did not occur until again in 1930 when Cambridge needed more water. The additional water was obtained by the full development of its own areas and the question of entering the Metropolitan will not come up again for a good many years if and when additional water is needed. Unfortunately, at that time, apparently, the entrance fee will be a good many times larger than Mr. Kennison proposes for the present. It would seem as if some way ought to be devised to even this up so as to fit more nearly the requirements of the municipality that may be interested in joining at a particular time.

Referring now to the maintenance charge. This seems to be worked out in a better way than the old one, and the results are better though they still appear to be high in some cases compared with the cost of operating an existing supply. In 1930 Cambridge was to pay a maintenance charge of $312,000 and was to receive a credit of $208,000, making a payment of $104,000 a year net even if it used no water. Under Mr. Kennison's present proposal Cambridge would pay $86,000 a year when it used no water. As the maintenance charges are now greater than they were in 1930 this is a greater reduction than the difference of $18,000 between these two figures. I have estimated that the 1930 figure would be approximately $60,000 more with the present total maintenance so that the reduction would be from $144,000 to $86,000, approximately 40%. This is getting closer to what a city might possibly afford considering the safety provided by an additional supply and the assurance of a future supply as the present one becomes inadequate.

It is interesting to compare the totals with the 1930 figures. In 1930 the total cost of running the Cambridge water supply was $468,000. Joining the Metropolitan would have increased this by a total of $301,000 a year or approximately 64%, even with the use of practically no water at all. According to the present rates Cambridge in 1939, I have not the 1940 figures, with a total cost of operating the system of $465,500, adding the interest and amortization on $183,000, of say $11,000 and the proposed additional maintenance fee of $86,000, the additional cost would now be, if Cambridge went into the Metropolitan using no water, $97,000, an increase of a little over 20%. Cambridge has one of the lowest water rates, I believe, in the state, 10¢ per 100 cubic feet, and as long as its supply is in its present good condition both from a point of view of quality and adequacy I should question whether the city would want to enter the Metropolitan now but it certainly is clear that the greater cost of around 20% creates an entirely different picture on which future negotiations could begin than the additional cost of 60%, which was the amount ten years ago and, of course, could not even be discussed.

I cannot follow Mr. Kennison's insurance plan from two points of view. If I am correct about it, it forces communities selected by the state to join the Metropolitan by law, the State Board of Health being given the decision as to which communities have supplies inadequate as to quality and quantity. The quality of water of every community, whether in the Metropolitan or not, is now followed by the Board of Health. It may be willing to determine the adequacy of these supplies for this purpose but I should not think it would want the job. If the additional safety due to having the Metropolitan supply is worth having one can be sure that the municipality will avail itself of it, but let's avoid any forcing by law. This is a matter of insurance and if it is worth while, it is certain that it will be paid for.

There are a great many transactions made between people and corporations: *A* has something to sell which *B* may wish to buy, and the transaction is made on the basis of trade which takes into account many special factors in each case and thus is fair to each even though it may be inconsistent with other trades made by the same parties. I am going to venture to suggest that it might be possible for the Metropolitan District, in dealing with the municipalities that are not now members, to make arrangements that might not necessarily be

entirely consistent but that would be of such nature as to be of benefit both to the District and to the community.

CHARLES W. SHERMAN.[4] What I have to say is not really a discussion of Mr. Kennison's paper, but rather it is a criticism of the philosophy underlying the principle of entrance fees to the Metropolitan Water District and of annual assessments for Metropolitan water.

I have only praise for Mr. Kennison's paper. He has given us an admirable description of the development of the Metropolitan water system, of the methods of financing that have been followed, and of what is likely to be done along these lines for a long period of years. He has brought together much information that was not easily accessible to most of us, and it is going to be extremely useful to the member communities of the District and to others contemplating applying for membership.

I presume that my comments will be looked upon by the men connected with the Metropolitan system, and perhaps by all of you, as rank heresy. That would have been my own opinion of such ideas many years ago, when I was employed on the Metropolitan water works, and for a considerable time thereafter; but in the course of years my ideas have gradually been modified. I now feel that the present method of financing the Metropolitan water works is entirely wrong, illogical in every way, and based upon false premises.

The basic idea of establishing an "entrance fee" for membership in the Water District is that the member municipalities own their proportionate shares in the works. This idea has no basis in fact. The title to the works is and always has been in the Commonwealth of Massachusetts, and a member municipality has no more proportionate ownership than, for instance, the city of Pittsfield. The charge for joining the District is no more equitable than it would be for, let us say, the City of Cambridge to say to a large manufacturer wishing for water service: "Yes, we should like to have you take water from our works, but before a connection can be made you must pay a sum equivalent to your proportionate share of the cost of our works if they had been built by the water takers". Imagine, if you can, a water company established for the purpose of developing a large supply, selling water at wholesale to a group of communities, and subject to

[4]Consulting Engineer, Boston, Mass.

the jurisdiction of a competent public utility commission. How far would it get with any such demand? It is my contention that the State, in establishing the Metropolitan water works, has practically adopted the functions of such a wholesale water company and should govern its operations by principles that would be equitable if the works were privately, instead of publicly, owned.

Here is the Metropolitan Commission in the position of such a company with a developed supply largely in excess of the needs of its present users, anxious to have additional communities "enter" the District and share in the expense, and yet setting fees so high that few if any of those who should be clamoring for admission feel that they can afford to do so. Is that good business?

I am not ignoring the fact that the present method of computing entrance fees results in great reductions as compared with what they would have been on the basis formerly used, yet we still find that many cities and towns that ought to be in the District feel that they cannot afford to come in.

Then there is the matter of the annual assessment. If charges for water are in the nature of taxes, then there may be logic in the present method; but if, as I believe is the case, they are charges for a commodity, then that commodity should be sold at reasonable rates logically computed. Imagine the wholesale water company, which I have already suggested, as announcing to its customers: "We cannot tell you in advance what you will be charged for water; at the end of the year we will compute what we have paid out for operation, fixed charges (including retirement of bonded indebtedness), and such extensions as we have made without borrowing funds, and we will then charge you next year enough to cover this outlay—the charge being proportioned in part on your ability to pay and in part on the actual consumption of water." What standing would such a proposition have with a utility commission?

The State would expect a corporation chartered by it to perform a public service to conform to definite regulations. When it enters into a commercial operation of a similar kind, should it not be governed by similar rules?

I am not suggesting that the actual price paid for water should be the same for all communities. The principles of minimum charges based upon potential demand, and of sliding scales of rates, are well

established, and could be applied to wholesale operations as well as to those of the individual communities.

A third point may be worthy of mention, but it has no necessary relation to those already discussed. It is whether or not it is desirable to continue to have the water supply system operated by one agency and the distribution by a number of others. I understand that the Metropolitan Water Board of London not only owns and operates the supply works, but also the distribution pipes, and that it furnishes water to individual customers. That, of course, is the largest water works in the world. In our own vicinity, the Hartford Metropolitan District follows a similar method. Whether or not such a procedure would be advantageous here is a matter that has never been studied, so far as I know, and I have no opinion on that matter.

The other discussions on this paper have, I believe, been prepared in advance, and relate especially to the applicability of the financing methods described by Mr. Kennison to the conditions in individual communities that might join the Metropolitan District or that already are members. I have not prepared any discussion in advance but have attempted to put before this meeting some ideas regarding the propriety and logic of charges for Metropolitan water which, so far as I know, have never been publicly discussed, but which I believe are worthy of serious consideration.

WILLIAM W. BRUSH.[5] It is not clear what these entrance fee charges are based on, and how they are proportioned.

MR. KENNISON. The base is the amount that has been paid off to date on bonds for the new supply and the pressure aqueduct. In getting the proportionate share of any one or more of these fifteen cities and towns, the base is proportioned among all the thirty-five towns, members as well as non-members, one-third on the basis of their respective valuations and two-thirds on the basis of consumption, counting the consumption of all except the present members as nothing. The effect is the same as taking only one-third of the bond payments and proportioning that third on the basis of valuation. It is something the same as the present law requires in the case of member towns not using the water, except that Newton has been getting out of it rather cheaply on the basis of only one-fifth of its valuation.

MR. BRUSH. Then, the amount to be paid would be what the

[5]Editor, *Water Works Engineering*, New York, N. Y.

town or city would have paid if it had been in at the time when the new work was started but had taken no water. Is that approximately correct?

MR. KENNISON. Yes. It is the amount that that town would have paid for the cost of the new works only, and not what it would have paid for the cost of the old works, assuming that it and the other 14 prospective members had been in from the beginning, and further assuming that the law, instead of reading as it does, assessing such towns on only one-fifth of their valuation, had been changed so as to assess them on the full valuation.

HAROLD L. BRIGHAM.[6] All of this talk about the Metropolitan system and the entrance fees is very interesting, especially to communities that are located near the Metropolitan supply works but not within the District limits. Does the entrance fee include the cost of the old works?

MR. KENNISON. No. Not only that, but the new member is insured, by the method of computation of the fee, against having to pay for any of the old works in the future. The part that must be assessed in the future is known to a cent and that is deducted from the base at the present time.

MR. BRIGHAM. Would you say that new members would be obligated to pay for part of the Sudbury works, for instance?

MR. KENNISON. No, not on the suggested basis.

MR. BRIGHAM. Under the present law, would they?

MR. KENNISON. The law at the present time merely says that new members pay such entrance fees as the Commission may determine. It is just a matter of the Commission's policy in any case. The existing law applies only to towns that are within ten miles of the State House. Towns like Marlborough, which are outside but within range of the District's aqueducts, are subject to whatever action the Commission might take. They might be permitted by the Department of Public Health to purchase water in an emergency or they might get a special act.

MR. BRIGHAM. Isn't considerable thought being given to increasing the present Metropolitan Water District from ten miles to something like twenty-five miles, so as to bring in other customers?

MR. KENNISON. Yes, a number of other suggestions have been made in addition to those in this paper, such as increasing the size

[6]Superintendent, Marlborough, Mass.

of the District or permitting the District to sell to any city or town within reach, even though it requires the construction of extensive connections and the financing of them. It is true that such suggestions have been made in the past and are rather live issues.

LYNN H. ENSLOW.[7] May I ask a question as a rank outsider as to the method of financing this Metropolitan system. It does strike an outsider as being a rather high-pressure method of getting these fifteen municipalities into the system when you throw before them a sliding scale that goes up at an alarming rate every year. What is the ground for it?

The other thing I am going to ask is this: Assuming that Cambridge wished to protect itself by paying an entrance fee, and assuming that it then did not decide to go through with it, could it withdraw and get any of the money back?

MR. KENNISON. There are two reasons why the base goes up so rapidly. One is that we are continually, at the present time, paying heavily for these new works. For instance, we have to date paid off bonds of a little over $12,000,000, and five years from now we shall have paid off over $21,000,000. The other reason is that we give to each entering town credit for the share, which it must unavoidably assume under existing legislation, of many old and some obsolete works. That obligation which they assume and for which they will be assessed next year if they join this year is about two and a half billion dollars, but in five years from now it will be about one and a third, and in ten years from now it will be less than a million dollars. Answering your second question, a town cannot, under any provision of law, leave the District after once joining it.

MR. ENSLOW. That brings up another question: Why should you issue a thirty-year bond?

MR. KENNISON. That is a matter of the law. When the works were first started they could issue forty-year sinking fund bonds. Then the state financing was changed substituting serial bonds for sinking fund bonds and changing the term to thirty-years. The first bonds for our new supply were issued for a twenty-year term, the demand at that time being for a short term; but that legislation was revised in 1927, and since then we have been issuing bonds for a thirty-year term.

[7]Editor, *Water Works and Sewerage*, New York, N. Y.

PROCEEDINGS

Sixtieth Annual Convention

Boston, Massachusetts

September 23 to 26, 1941

The following is a synopsis of those parts of the proceedings of the Sixtieth Annual Convention that appear to be of value for the record.

The Sixtieth Annual Convention of the New England Water Works Association was held at the Hotel Statler, Boston, Massachusetts, September 23 to 26, 1941.

Tuesday, September 23

Morning Session

The convention was called to order by President Carlton at 10:45 A.M.

Administrative Reports

The Annual Reports of the Secretary, Treasurer, Editor, and Finance Committee were presented (see p. 572), accepted, and ordered placed on file.

The Report of the Committee on Reciprocal Relations with the Institution of Water Engineers was read by E. Sherman Chase, accepted, and ordered placed on file. (See p. 584).

The Report of the Committee on Revision of the Constitution was read by Percy A. Shaw, accepted, and copies ordered distributed to the membership.

Harold L. Brigham presented the Annual Report of the Committee on New Members. This report was accepted and ordered placed on file.

The Annual Report of the Legislative Committee was read by Arthur C. King, accepted and ordered placed on file. (See p. 586).

Warren J. Scott presented the Annual Report of the Committee on Committees. This report was accepted and ordered placed on file. (See p. 588).

The Annual Report of the Committee on Water Works Educa-

tion was presented and delivered to the Executive Committee for action. (See p. 597).

The following progress reports were received: Activities of the Sectional Committee B 16 on Standardization of Pipe Flanges and Fittings and its Sub-Committees—F. A. Barbour and W. R. Conard; and Activities of the Sectional Committee on Cast Iron Pipe—A. L. Shaw and W. R. Conard.

Closing of Polls and Appointment of Tellers

The President declared the polls closed and appointed William B. Duffy and Roger G. Oakman tellers to canvass the ballots.

Luncheon Session

The Luncheon Meeting was addressed by Daniel M. Sullivan who read the following greetings from His Honor Maurice J. Tobin, Mayor of Boston.

"Few people realize the important function you men perform in the every-day life of America. To assure adequate and pure supplies of water is of paramount importance. In that respect, it must be pointed out that New England has the purest water of any section. In the past three and one-half years I have traveled to many parts of the country and can say from experience that the water supplies in this area are the best.

"I hope while you are here that you can find time to visit the Albany Street yard of our water department and its offices at City Hall. At the latter place we can exhibit with pride a new billing system that, during the past year, has resulted in our collecting 97 per cent of the outstanding water bills. We were helped in carrying out this idea by getting legislation that put additional teeth into the statute which places a lien on real estate in cases where water rates are due. The result has been gratifying, in view of our efforts to place the city's finances on a better footing, and I know that if you care to drop in and inspect the system Dan Sullivan, head of that municipal division, will be glad to explain how his department has been taken out of the red and is now showing an operating surplus.

"The seven-year period from 1930 to 1938 showed an aggregate deficit of nearly $1,000,000; during the years 1938, 1939 and 1940, that has been transformed into a surplus over expenditures of $1,830,65. That proves it can be done.

"Your convention has a busy program laid out and I assume that no small part of it has to do with defense matters. I hope your sessions will be fruitful. I wish for your organization continued success and I hope you will meet here again within the next three years."

Secretary Gifford read the following list of new members:

Members: John A. Bellizia, Engineer, Massachusetts Department

of Public Health, Arlington, Mass.; Henry Campbell, Elizabeth, New Jersey; Arthur T. Clark, Manager, Water and Sewage Works Manufacturers Association, New York, N. Y.; George S. Ryan, Public Works Department, City of Boston, Dorchester, Mass.; John F. Ford, Water Commissioner, Somerville, Mass.; George Wheeler Coffin (reinstatement), with Fay, Spofford & Thorndike, Boston, Mass.; William Arnold Steinhurst, Massachusetts Department of Public Health, Brookline, Mass.; Robert Leslie Wiley, Salem Water Dept., Salem, Mass.; Wyman Richardson Stone, Sanitary Engineer, Connecticut State Department of Health, West Hartford, Conn.; Matt Armo Hautala, Town Engineer, Rockport, Mass.; Harold D. Lamson, Superintendent Water Department, Foxboro, Mass.; Kenneth F. Knowlton, Superintendent and Chemist, Salem-Beverly Water Supply Board, North Beverly, Mass.; Michael B. Oates, Superintendent Water Department, Watertown, Mass.; James S. Goff, Associate Engineer, Water and Sewage, Camp Edwards, Hyannis, Mass.

Associate Members: The Ruberoid Company, Gloucester City, N. J.; D. L. Maher Company, Woburn, Mass.; Limestone Products Corporation of America, Newton, N. J.

Award of the Dexter Brackett Memorial Medal

Frederick Shepperd. Mr. President, honored guests, and members of the New England Water Works Association: It is my privilege today, representing the Committee on Award of the Dexter Brackett Memorial Medal—which Committee includes Leonard W. Trager, Allan F. McAlary and myself—to perform a very pleasant task in presenting this medal.

In selecting the paper for the award, the Committee had a very difficult task on its hands, for many papers were read and printed in the Journal of 1940, making it hard to arrive at a selection agreeable to all. When I mention that each member of the Committee had a different selection at the start, you can understand how little the difference was in the merit of the different papers considered.

I would like to say at this time that the Chairman of the Committee had splendid coöperation from the other two members, team work from each, and the fact that all arrived at a unanimous decision after comparatively little correspondence indicates a type of cooperation that makes things move.

The Committee was guided by the specifications laid down by the New England Water Works Association, that the award had to be made for the paper that it judged to be the most meritorious, bearing in mind its applicability to general water works practice.

The final decision was that the paper by John R. Baylis, Physical Chemist, Department of Public Works, Chicago, Illinois, entitled "Filter Operation and Maintenance," was entitled to the award. Mr. Baylis is no stranger among us. He has appeared on our program on various occasions and has on one occasion previously been honored by this Association as the recipient of the Dexter Brackett Memorial Medal. Unfortunately Mr. Baylis was not able to get here today, and I shall ask our mutual friend, Linn H. Enslow, to accept the medal for Mr. Baylis.

LINN H. ENSLOW. It naturally gives me a great deal of pleasure to accept this medal for John R. Baylis. As far as I know, Caleb Mills Saville, Robert Horton, and John R. Baylis are the only members of the Association who have been honored more than once with the receipt of this medal. Mr. Baylis has written the following letter:

"I should like to express appreciation of the honor conferred upon me by the New England Water Works Association for the Dexter Brackett Memorial Medal. Also I should like to express regret for not being able to attend the Convention. We are very busy trying to get additional contracts on the construction of the filtration plant for Chicago under way, and to be away two or three days might cause delay.

"The thrill of receiving such a high award cannot be explained adequately by words, it has to be experienced.

"One-half century ago there was being developed a new profession, the profession I have chosen for my life work—water purification. The place of this Convention is not far from where some of the greatest men of our profession received their early training. To be honored in the midst of such surroundings is indeed an inspiration.

"Permit me to express thanks to the Committee on Award for this high honor. It gives great encouragement to continue efforts to bring about better operation of water purification plants."

Afternoon Session

A progress report of the Committee on Rainfall and Yield of Drainage Areas was read by Arthur D. Weston, Chief Engineer of the Massachusetts State Department of Health, Boston, Mass.

A paper, "Water Conservation in New Hampshire," was read by

Richard S. Holmgren, Chief Engineer, New Hampshire Water Resources Board, Concord, N. H. Arthur D. Weston discussed the paper.

A paper, "Laying a Submarine Pipe in Portland Harbor in Winter," was read by Harry U. Fuller, Chief Engineer, Portland Water District, Portland, Me. Sidney S. Anthony, Abel Reynolds, Thomas H. Wiggin, and Linn H. Enslow took part in the discussion.

A paper, "Flow Tests on 30-inch Steel Pipe, Lined with Bitumastic Enamel in 1932," prepared by J. D. Carpenter of Gannett, Eastman and Fleming, Inc., Harrisburg, Pa., and George H. Roads, Superintendent, Panther Valley Water Company, Lansford, Pennsylvania, was read by Mr. Carpenter.

A moving picture, entitled "Behind the Water Tap," was presented by E. A. Sigworth, Industrial Chemical Sales Division of the West Virginia Pulp and Paper Company.

WEDNESDAY, SEPTEMBER 24

Morning Session

Francis H. Kingsbury presented a progress report of the Committee on Sabotage.

A paper, "Water Works Operation Under Emergency Conditions," was read by Harry E. Jordan, Secretary, American Water Works Association, New York, N. Y. Linn H. Enslow, Thomas H. Wiggin, W. W. Brush, E. Sherman Chase, H. L. Nelson, and Warren J. Scott took part in the discussion.

G. V. Doherty, Special Agent, Federal Bureau of Investigation, Boston, Mass., gave a talk on the "Activities of the F. B. I. in the Prevention of Sabotage." E. Sherman Chase, Linn H. Enslow, Thomas H. Wiggin, George F. Merrill, Harry U. Fuller, Adolph Mueller, E. W. Moore, and Arthur C. King took part in the discussion.

A paper, "Civilian Defense Organization in Massachusetts," was read by Arthur D. Weston, Chief Engineer, Division of Sanitary Engineering, Massachusetts Department of Public Health, Boston, Mass. Roger W. Esty, Fred Gibbs, Warren J. Scott, and Harold L. Brigham took part in the discussion.

Afternoon Session

Richard H. Ellis submitted a progress report of the Committee on Meter Specifications.

A paper, "Relining a Concrete Reservoir," was read by Horace J. Cook, Superintendent, Auburn Water District, Auburn, Me. Charles W. Sherman discussed the paper.

A paper, "The Edisto-Goose Creek Tunnel," was read by J. E. Gibson, Manager and Engineer, Water Department, Charleston, S. C. George Wadleigh of the West Virginia Pulp and Paper Company, Malcolm Pirnie, and Linn H. Enslow took part in the discussion.

A paper, "The Effects of Earthquakes on Water Distribution Systems," prepared by Professor Charles Gilman Hyde, College of Engineering, University of California, was read by Gordon M. Fair.

A demonstration of defense fire fighting equipment of the Boston Fire Department was given at Statler Park, Columbus Avenue.

THURSDAY, SEPTEMBER 25

Morning Session

George A. Sampson presented the Report of the Committee to consider the "Tentative Standard Specifications for Elevated Steel Water Tanks, Standpipes, and Reservoirs." It was voted to circulate the specifications to the membership and to submit their adoption by the association at a later time.

A paper, "Public Works Programming in Relation to Post War Problems," was read by William Stanley Parker, F.A.I.A., Consultant, National Resources Planning Board. Frank A. Barbour, E. J. Cleary, W. W. Brush, Warren J. Scott, Harry E. Holmes, Malcolm Pirnie, and Thomas H. Wiggin participated in the discussion.

A paper, "Water Charges to Municipalities in the Boston Metropolitan Area by the Metropolitan District Commission," was read by Karl R. Kennison, Chief Engineer, Metropolitan District Water Supply Commission, Boston, Mass. Henry F. Beal, Charles W. Sherman, Daniel M. Sullivan, Howard M. Turner, William W. Brush, Harold L. Brigham, and Linn H. Enslow took part in the discussion.

A paper, "Laboratory Investigations in the Treatment of Ranocas Creek Water for Fort Dix, N. J.," was read by Robert D. Mitchell, Assistant Engineer, Office of Malcolm Pirnie, Consulting Engineer, New York City. Malcolm Pirnie, Warren J. Scott, and Linn H. Enslow participated in the discussion.

Afternoon Session

Leslie K. Sherman read a progress report of the Committee for Survey of Ground Water Supplies in New England.

Papers on "Determination by Statistical Methods of the Average Service Life of Six-Inch Cast Iron Water Mains in Brooklyn, N. Y.," were read by Arthur V. Ruggles, Assistant Hydraulic Engineer, and C. Beverley Benson, Principal Statistician (Engineering), New York Public Service Commission. Thomas H. Wiggin, William W. Brush, Percy R. Sanders, and George F. Merrill took part in the discussion.

Papers on Ground Water Surveys in New England were presented as follows: "The Massachusetts Surveys," prepared by Maurice L. Brashears, Jr., Assistant Geologist, U. S. Geological Survey, Jamaica, N. Y. (read by John G. Ferris) and "The Connecticut Surveys," by John G. Ferris, Junior Engineer, U. S. Geological Survey, Jamaica, N. Y. These papers were discussed by Warren J. Scott and William W. Brush.

A paper, "Experiences by the Sanford Water District in Water Treatment," was read by Horace L. Clark, General Manager, Sanford Water District, Sanford, Me. Allen M. Symonds, Linn H. Enslow, George F. Merrill, William W. Brush, and Henry T. Gidley took part in the discussion.

A moving picture, "Health and the Cycle of Water," was shown through the courtesy of Thomas F. Wolfe, Research Engineer, Cast Iron Pipe Research Association, Chicago, Ill.

FRIDAY, SEPTEMBER 26

Morning Session

President Carlton in the chair.

REPORT OF TELLERS OF ELECTION

Total number of ballots cast	228
Ballots counted	227
For President: Francis H. Kingsbury	227
For Vice-President: Horace L. Clark	227
For Director: Arthur L. Shaw	226
For Treasurer: Abel Reynolds	226

(Signed) WILLIAM B. DUFFY
ROGER OAKMAN

The President presented the President Elect.

WARREN J. SCOTT presented the following resolution:

RESOLVED that a vote of thanks be extended to the Water and Sewage Works Manufacturers Association for its share in contributing to the success of this convention, and to Commissioner Reilly and Chief Pope of the Boston Fire Department and Chief Kenney in charge of the Auxiliary Fire Unit for the interesting demonstration of fire apparatus and methods. We would also at this time extend our thanks to Mr. Jay Herman Smith, chairman of the exhibit committee, for his able handling of the exhibits not only at this convention but during past years, and to Mr. Clinton Inglee for his untiring efforts and devotion to duty during his service as chairman of the entertainment committee. Thanks are also extended to the ladies' entertainment committee and its most efficient chairman, Mrs. Roger G. Oakman.

The resolution was duly seconded and unanimously adopted.

Superintendents' Session

Roger W. Esty, Superintendent, Danvers Water Works, Danvers, Mass., presiding.

A paper, "Financing Water Main Extensions," was read by William P. Melley, Superintendent Water Department, Milton, Mass. Abel Reynolds, Roger G. Oakman, Leland G. Carlton, Allan F. McAlary, William W. Brush, Donald C. Calderwood, Theodore L. Bristol, G. E. Hawkins, J. E. Gibson, George C. Brehm, Arthur G. King, Linn H. Enslow, and Frank J. Gifford took part in the discussion.

A paper, "Municipal Water Charges to Industrial Users," was read by Arthur C. King, Superintendent, Water Works, Taunton, Mass. Theodore L. Bristol, Linn H. Enslow, J. E. Gibson, Roger W. Esty, George C. Brehm, Theodore L. Cate, Stephen H. Taylor, Walter P. Schwabe, William Naylor, Harry U. Fuller, and Donald C. Calderwood participated in the discussion.

A paper, "Water Works Inventories in Relation to National Defense," was read by G. E. Lourie, Superintendent, Water Department, Bristol, Conn. The paper was discussed by Warren J. Scott, Theodore L. Cate, Harry U. Fuller, George C. Brehm, Francis H. Kingsbury, Sidney S. Anthony, Stephen H. Taylor, and Harry U. Fuller.

A paper, "Demonstration of Model Analysis of Water Distribution Systems," was read by Harold A. Thomas, Jr., Instructor in Sanitary Engineering, Harvard Graduate School of Engineering,

Cambridge, Mass. The delivery of the paper was followed by a physical demonstration of the apparatus.

Chemists' Session

J. Elliot Hale, Supervising Sanitary Engineer, Bureau of Health, Department of Health and Welfare, Augusta, Me., presiding.

A paper, "Recent Developments in the Use of Hexametaphosphate in Water Treatment," was read by Owen Rice, Hall Laboratories, Pittsburgh, Pennsylvania. The discussion was opened by E. W. Moore, Associate Professor of Sanitary Chemistry, Harvard Graduate School of Engineering, Cambridge, Mass., and participated in by Leslie K. Sherman, Stuart E. Coburn, Allen M. Symonds, and Henry G. Gidley.

A paper, "Relative Effectiveness of Aeration and Activated Carbon in the Control of Tastes and Odors," was read by George G. Bogren, Sanitary Engineer, Weston and Sampson, Boston. Stuart E. Coburn, E. A. Sigworth, W. A. Helbig, and Samuel M. Ellsworth took part in the discussion.

President CARLTON. It has been my thought that this has been a very successful convention. Our registration has proved that. The registration has gone up to 720. Our papers have been interesting and instructive. The attendance at the various sessions has been excellent. Our entertainment has been exceptionally fine.

[There being no further business to come before the convention, adjournment was taken at 12:30 o'clock P.M.]

PRESIDENTIAL ADDRESS

By Leland G. Carlton, Retiring President

As the Sixtieth Annual Convention of the New England Water Works Association draws to a close, we as members can look back to many achievements in a vital field of service in the scheme of modern society. The water works man has made notable progress in purifying, transporting and delivering his commodity to the consumers. While much of this work has been complex and difficult to accomplish, the layman has accepted the results with little thought; in fact, the expression "as easy as turning on the faucet" has become idiomatic. But now, in these days of stress, the importance of the water supply of a town or city is becoming more fully recognized and appreciated. The burden of continuing our service in a program of national preparedness, which brings with it a scarcity of labor and material, together with the necessity of safeguarding the supply against the possibility of sabotage, has thrust a tremendous responsibility upon us.

We have much to learn from the experiences of our fellow water works men in England, who, under the most difficult conditions and with limited resources are "muddling through" with great courage and efficiency, until the day of victory. We Americans, employed in the same field of endeavor, must continue to maintain a normal supply and, at the same time, be ready to meet the increasing demands of industry and production. Behind the turbines, the mills, the airports, the shipyards, the fundamental element of water must be easily obtainable, and must be provided in satisfactory quantity and quality—provided by the water works man, in fact, gentlemen, by you and me.

We must be prepared to deal with all eventualities. We must coöperate to the utmost with the proper authorized committees on defense. We must keep our counsel. We must have auxiliary sources of supply, both for water and materials, ready to be drawn upon when the emergency comes. We must have competent, trustworthy personnel. In other words, we must have an integrated, self-sufficient utility. We of the New England Water Works Association must make ourselves a pattern of public service!

I have appreciated the honor of serving you as a president, and am gratified that this Association is succeeding in its endeavor to keep the members informed of new developments and new solutions to old problems in all aspects of water works and water supply. Our annual reports show a steady membership and a sound financial condition. The papers we have heard this year at our meetings have continued to be of the highest calibre. Attendance at the meetings has increased. This year an important Committee on Sabotage was appointed, under the able leadership of your incoming President, Francis H. Kingsbury.

I want to express my appreciation for the work of our Secretary, Treasurer, and Editor, and of those who have contributed so generously to our meetings and JOURNAL. I want especially to thank the members of our technical committees, who have given much time and thought to their commitments. The Program Committee, under the chairmanship of Samuel M. Ellsworth, has done an especially fine job in making our meetings a "must" for the average water works man. I want also to thank the Committee on Committees and its chairman, Warren J. Scott, for so ably coördinating the activities of our twenty-five technical committees; for making pertinent recommendations; and for throwing out committees which have long outlived their usefulness. Lastly, but not by any means least, I want to thank the Water and Sewage Works Manufacturers for their efforts and coöperation in making this convention a memorable success.

Annual Report of the Secretary

Mr. President and Gentlemen of the New England Water Works Association: The Secretary submits herewith the following report of the changes of membership during the past fiscal year, and the general condition of the Association.

The present membership is 798, constituted as follows: 9 Honorary Members, 647 Members, 1 Junior Member, 121 Associate Members, and 20 Corporate Members.

MEMBERSHIP

September 1, 1940.	Honorary Members, Total		9		
	Withdrawals	0	0	9	
	Elected	0		0	9
September 1, 1940.	Members, Total		659		
	Withdrawals:				
	Resigned	17			
	Died	8			
	Dropped by Executive Committee	22	47	612	
	Elected:				
	September, 1940	12			
	November, 1940	4			
	December, 1940	8			
	January, 1941	3			
	February, 1941	2			
	March, 1941	2			
	April, 1941	2		33	
	Reinstated:				
	September, 1940	1			
	February, 1941	1		2	647
September 1, 1940.	Juniors, Total		1		
	Withdrawals	0	0	1	
	Elected	0		0	1

September 1, 1940.	Associates, Total		111		
	Withdrawals:				
	Resigned	1	1	110	
	Elected:				
	September, 1940	8			
	November, 1940	1			
	February, 1941	2		11	121
September 1, 1940.	Corporates, Total		21		
	Withdrawals:				
	Resigned	1	1	20	
	Elected	0		0	20
					798
September 1, 1940.	Total Membership				801
September 1, 1941.	Total Membership				798
	Net Loss				3

ELECTIONS

Members

September 24, 1940. Albert E. Brown, Allan G. Davenport, Francis M. Hennessey, Charles M. Morey, William J. Orchard, Malcolm J. Quimby, Arthur V. Ruggles (Reinstated), Richard H. Smith, Nat S. Stevens, Dennis F. Sweeney, Robert C. Thompson, Otis S. Tolman, and Edward L. Tracy. (13)

November 21, 1940. Ernest Goobie, Louis C. Campbell, William A. Harris, and Herbert Scott-Smith. (4)

December 19, 1940. Peter Bolton, Delwyn K. Barnes, Charles E. Burrill, Nicholas Ciaburri, John B. Kennedy, Russell L. MacDonald, Joseph A. McCarthy, and George L. Winslow. (8)

January 16, 1941. Henry B. Chandley, Edwin C. Goehring, and Hugh J. Loughlin. (3)

February 20, 1941. Edward B. Bell, Laban C. Morrill (Reinstated), and Robert W. Sayles, Jr. (3)

March 20, 1941. Kenneth H. Holmes and Ernest E. Erickson. (2)

April 24, 1941. Frederick Scott Gibbs and Robert Kaufman. (2)

Associates

September 24, 1940. The Bristol Company, Continental Pipe Manufacturing Co., Inc., Electro Rust-Proofing Co., Flexible Pipe Cleaning Co., The Gorman-Rugg Co., Omega Machine Co., Paint Engineers, Inc., and Rusta Restor Corp. (8)

November 21, 1940. The Allpax Company. (1)

February 20, 1941. American Smelting and Refining Company, and Calgon, Inc. (2)

Withdrawals

Members

Resigned: Elliott R. B. Allardice, Louis H. Alman, Harold W. Baker, George J. Cote, Merritt E. Cutting, Chester M. Everett, William F. Herlihy, Franklin Henshaw, Thomas F. Lawlor, Birdsill B. McIntyre, Thomas F. Monahan, Sol Pincus, Harry H. Smith, George A. Stetson, Joseph W. Wattles, 3rd., William E. Young, J. L. Van Ornum. (17)

Died: George O. Adams, Frank Becker, Francis W. Dean, George G. Earl, James A. Hancock, H. S. R. McCurdy, Charles L. McNeil, Sidney Smith. (8)

Dropped by Executive Committee: Dwight L. Agnew, S. Alfred Benson, Maurice Burwick, Harold L. Carter, Henry F. Ferrick, G. Ferullo, Albert H. Fournier, David P. Geary, Thomas Hargreaves, Frank E. Hussey, C. F. Jost, Thomas A. La Cava, John P. Lynch, Edward F. McCormack, John D. Mackay, Laban C. Morrill, Leo T. Purcell, Benjamin G. Sargent, Ellsworth B. Tolman, Raymon F. Wagner, Henry Wiesner, Jr., John S. Wise. (22)

Associates

Resigned: The Pardee Engineering Co. (1)

Corporate

Resigned: The Rockville Water & Aqueduct Company. (1)

Receipts for the Fiscal Year September 1, 1940 to September 1, 1941.

Entrance Fees			$ 202.00
Annual Dues:			
Juniors	$ 3.00		
Members	2,436.55		
Corporates	160.00		
Associates	1,240.00	$3,839.55	
Fractional Dues:			
Members	$ 77.50		
Associates	25.00	102.50	
Past Dues:			
Members	$ 184.00		
Associates	40.00	224.00	

1941-1942 Dues:			
Members	$ 830.50		
Corporates	40.00		
Associates	790.00	1,660.50	
Total Dues			$5,826.55
Dividends and Interests			356.36
Advertisements			3,547.40
Subscriptions			460.50
Journals			87.72
Reprints			12.00
Sundries			75.48
Total Receipts			$10,568.01
There is due the Association:			
Entrance Fees	$ 16.00		
Dues	698.00		
Advertisements	51.00		
Journals	1.00		
Subscriptions	91.00		857.00
Total			$11,425.01

Respectfully submitted,

FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer

President and Members of the New England Water Works Association:

I herewith submit the annual report of the Treasurer of the New England Water Works Association for the year ending August, 31, 1941:

Statement of Cash Receipts and Disbursements

General Fund

For the Year ended August 31, 1941

Receipts (exclusive of dues paid in advance)			
Initiation Fees		$ 202.00	
Dues, 1940-1941 and Prior Years		4,166.05	
Interest		356.36	
From Publication of Journal			
Advertisements	$3,547.40		
Subscriptions	460.50		
Sale of Journals	87.72		
Sale of Reprints	12.00		
Sale of Halftones, Electros, etc.	30.84	4,138.46	
Miscellaneous			
Membership Certificates	34.50		
Membership Buttons	1.00		
Sale of Programs	9.14	44.64	
Total Receipts			$8,907.51
Disbursements			
Publication of Journal			
Printing	2,630.14		
Plates	665.00		
Reporting	365.77		
Reprints	20.25		
Stationery and Postage	137.33		
Editor's Salary	500.00		
Sundry	95.91	4,415.00	
Office and General			
Certificates of Membership	17.19		
Secretary's Salary	400.00		

Assistant Secretary's Salary	1,437.50		
Treasurer's Salary	100.00		
Treasurer's Bond	12.50		
Printing, Postage and Stationery	215.21		
Office Supplies and Expense	116.07		
Office Rent	1,200.00		
Electricity	47.46		
Telephone and Telegraph	148.84		
Audit	65.00		
Social Security Taxes	166.13		
Donation, Institution of Water Engineers, England	101.50		
Library Books and Expense	49.57		
Sundry	126.68	4,203.65	
Meetings and Committees			
Badges	59.38		
Water Works School	125.00		
Printing, Postage and Stationery	825.64		
Convention Expense	224.82		
Sundry Expense	63.55	1,298.39	
Total Disbursements			9,917.04
Excess of Disbursements over Receipts (exclusive of dues paid in advance)			1,009.53
Dues Paid in Advance			1,660.50
Excess of Receipts over Disbursements, Exhibit A			650.97
Balance, General Cash, August 31, 1940			4,128.23
Balance, General Cash, August 31, 1941			
Represented by			
Cash in First National Bank of Boston		4,729.20	
Cash in Office		50.00	
			$4,779.20

STATEMENT OF ASSETS AND FUNDS

As at August 31, 1941

Assets

Cash in Banks, Invested Funds		
City Five Cents Savings Bank, Haverhill, Massachusetts	$ 2,000.00	
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	2,068.46	

Franklin Savings Bank, Boston, Massachusetts	2,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	2,000.00	
Home Savings Bank, Boston, Massachusetts	2,000.00	
Mechanics Savings Bank, Reading, Massachusetts	2,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	2,000.00	
The People's Savings Bank, Worcester, Massachusetts	2,000.00	
Suffolk Savings Bank, Boston, Massachusetts	2,000.00	
Total Invested Cash		$18,068.46
General Fund		
Cash, First National Bank of Boston	4,729.20	
In Office	50.00	
	4,779.20	
Furniture and Fixtures	1,180.00	5,959.20
		$24,027.66

Funds

Invested Funds		$18,068.46
General Fund		
Balance, August 31, 1940	5,308.23	
Add Excess of Receipts over Disbursements, Exhibit B	650.97	
Balance, August 31, 1941		5,959.20
		$24,027.66

Note: The statement above, prepared on a cash basis, includes dues paid in advance, $1,660.50 and does not reflect the following:

Accounts Receivable, Dues and Initiation Fees	$ 714.00
Due on Account of Advertising and Other Miscellaneous Charges	143.00
	$ 857.00

No depreciation has been taken on Furniture and Fixtures.

Boston, September 15, 1941

To ABEL REYNOLDS, *Treasurer*,
New England Water Works Association,
Providence, Rhode Island.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the fiscal year ended August 31, 1941. In connection therewith we have reviewed the accounting procedures of the association and have examined accounting records and other supporting evidence, by methods and to the extent we deemed appropriate.

We traced all recorded receipts into the depositary banks, verified the general fund bank account and petty cash fund as at August 31, 1941, and examined properly approved vouchers for all disbursements. We also verified by direct confirmation the investment funds on deposit in savings banks.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related general fund cash statement present fairly the position of the New England Water Works Association at August 31, 1941, and the recorded cash receipts and disbursements for the fiscal year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed) SCOVELL, WELLINGTON & COMPANY

The Report of the Auditors reflects the actual transactions for the year, as shown by the books, kept on a cash basis.

However, in order that the membership of the Association may get a true picture of the years' operations, that is, applying to the year ending August 31, 1941, the dues for that year collected prior to September 1, 1940, and a similar application for the year ending August 31, 1940, I believe a better understanding of the conditions will be had.

Income Statement and Comparison on Annual Basis

			Increase or	
Receipts	1939-1940	1940-1941	Decrease*	
Dues and Fees	$5,786.40	$6,408.05	$621.65	
Interest	378.53	356.36	*22.17**	
Publication of JOURNAL	4,464.83	4,138.46	*326.37**	
Miscellaneous	32.91	44.64	11.73	
		$10,662.67	$10,947.51	$284.84
Disbursements				
Publication of JOURNAL	$3,846.46	$4,415.00	$568.54	
Office and General	4,292.85	4,203.65	*89.20**	
Meetings and Committees	1,297.37	1,298.39	1.02	
		9,436.68	9,917.04	480.36
Operating Profit		$ 1,225.99	$ 1,030.47	*$195.52**

It was not possible to have these comparisons audited by your Auditors in the short time intervening between the receipt of their report and this meeting, but they are compiled from the auditors' reports for the two years in question, and I include them as a part of my report for the year ending August 31, 1941.

Respectfully submitted,

ABEL REYNOLDS, *Treasurer.*

Annual Report of the Editor

To the New England Water Works Association:

The Editor submits herewith the following report for the year ending August 31, 1941.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1940, and March and June, 1941, issues of the Journal is included in the Report of the Treasurer.

Table 1.—Statement of Material in September and December, 1940, and March and June, 1941, Issues of the Journal of the New England Water Works Association

Date	Papers	Proceedings	Total Text	Index	Advertisements	Cover and Contents	Insert Plates	Total	Total Cuts
September, 1940	78*	2	80	0	42	4	0	126	8
December, 1940	113	31	144	8	42	4	0	198	17
March, 1941	132**	4	136	0	42	4	0	182	24
June, 1941	172	8	180	0	40	4	3	227	41
Total	495	45	540	8	166	16	3	733	90

*Including Comprehensive Index 1882 to 1939.
**Exclusive of Specifications for Cast-iron Pipe and Fire Hydrants (102 pages).

Table 2 gives a comparison of the Journal for the past year with preceding years.

Size. The four issues contained 733 pages, of which 540 were text.

Cost. The gross cost of the Journal was $4,415.00 equivalent to $5.52 per member; the net cost was $276.54, equivalent to $0.35 per member. It should be noted that there were included in the four issues of the Journal a comprehensive index to the Publications of the Association from 1882 to 1939 and 102 pages of standard specifications.

Reprints. Reprints of each paper have been furnished to the author at cost.

TABLE 2—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.
FOUR ISSUES FOR FISCAL YEAR ENDING AUGUST 31.

	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941*
Average edition (copies printed) .	1,200	1,125	1,100	1,100	1,100	1,100	1,100	1,000	1,100	1,100
Average membership	813	805	796	786	770	772	785	795	796	800
Circulation at end of year	957	930	928	918	903	920	943	946	967	944
Pages of text	437	420	499	470	477	425	510	488	565	540
Pages of text per 1,000 members ..	537	522	627	598	619	561	650	614	710	675
Total pages, all kinds	644	594	645	643	642	627	699	670	762	733
Total pages per 1,000 members ..	790	738	811	808	834	812	890	843	957	918
GROSS COST:										
Total	$5,024.03	$4,712.16	$5,411.30	$4,780.75	$5,880.68	$5,040.86	$4,658.05	$4,119.30	$3,846.46	$4,415.00
Per page	7.80	7.93	8.39	7.54	9.16	8.04	6.66	6.15	5.05	5.66
Per member	6.18	5.85	6.80	6.08	7.64	6.53	5.93	5.18	4.83	5.52
Per member per 1,000 pages ..	9.62	9.85	10.53	9.46	11.89	10.41	8.49	7.13	6.34	7.53
Per member per 1,000 pages of text	14.30	13.94	13.62	12.93	16.01	15.01	11.63	10.61	8.55	10.21
NET COST:										
Total	$1,121.20	$1,176.77	$1,916.27	$1,332.99	$1,499.58	$489.13	$539.21	$306.77**	$618.37**	$276.54
Per page	1.74	1.98	2.97	2.07	2.34	0.78	0.77	0.46**	0.81**	0.38
Per member	1.38	1.46	2.41	1.70	1.95	0.63	0.69	0.39**	0.78**	0.35
Per member per 1,000 pages	2.14	2.46	3.73	2.64	3.03	1.01	0.98	0.58**	1.02**	0.47
Per member per 1,000 pages of text	3.16	3.48	4.83	3.61	4.08	1.46	1.35	0.80**	1.37**	0.64

*Including comprehensive index, 1882 to 1939 and 102 pages of standard specifications.
**Profit.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	798
Subscribers	121
Exchanges	24
Total	943

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,
(Signed) GORDON M. FAIR, *Editor.*

Report of the Finance Committee

To the Executive Committee of the New England Water Works Association:

Gentlemen: The Finance Committee submits the following budget for 1941-1942:

Estimated Revenue	
Initiation Fees	$ 200
Dues	5,300
Interest and Dividends	300
Journal	4,100
Miscellaneous	75
	$9,975
Estimated Expenditures	
Office	$4,600
Journal	4,000
Meetings and Committees	1,300
Miscellaneous	75
	$9,975

In preparing the budget careful consideration was given to income and expenditures for previous years. Owing to present conditions, the estimate for receipts for Journal was reduced and the fact that the membership list ($475.00) was not paid last year was noted.

An audit of the books by a certified public accountant will be found as a part of the Treasurer's Report.

(Signed) Henry T. Gidley, *Chairman*
Daniel M. Sullivan
W. Guy Classon

Report of Committee for Reciprocal Relations with the Institution of Water Engineers

To the New England Water Works Association: Your Committee for Reciprocal Relations with the Institution of Water Engineers recommended to the Executive Committee that a donation be sent to the Institution to be used for war relief in England. This recommendation was approved unanimously by the Executive Committee which appropriated the equivalent of 25 pounds, approximately $100 for this purpose.

Under date of August 8, this sum was transmitted to Colonel Frank Hibbert, President of the Institution of Water Engineers, and Water Engineer of Liverpool. The following is the letter of transmittal:

"Dear Colonel Hibbert:

"As a slight token of the cordial relations existing between our two great democracies, the New England Water Works Association, through its Committee for Reciprocal Relations with the Institution of Water Engineers, send herewith a draft for twenty-five pounds.

"It is the thought of our Committee that the Institution may know of some way of utilizing this amount to help alleviate the suffering of water works personnel resulting from the war. We are, however, leaving the disposition of this contribution entirely to your judgment.

"In closing may we express our admiration of the courage and fortitude shown by the British people, and our profound respect for the way in which the water supply services in England are being maintained under most trying conditions."

Under date of August 26th, Colonel Hibbert acknowledged the receipt of the donation by the following letter:

"Dear Mr. Chase:

"Your very kind letter of the 8th instant, enclosing draft for £25, was received with great satisfaction by the members of my Emergency Committee of the Institution of Water Engineers, and we have decided to place the amount to the credit of our Emergency Relief Fund. The members of the Institution will be notified in due course of your kind action and also of the welcome expressions contained in your letter, which I can assure you are very encouraging to us.

"We all admire and appreciate—indeed we are very thankful for the magnificent way in which the American people are giving us tangible support in the

present struggle, so much so that we have no doubt in our minds as to the ultimate success of our efforts in which we, as Water Engineers, believe we are contributing a part.

"Thanking you again, with best wishes to your good-self and your Association."

In conclusion your Commmittee recommends that it be authorized to express for the Association as a whole its great admiration for the fortitude shown by the British people in general and the water works profession in particular during the severe trials to which they have been and are now being so ruthlessly subjected.

Respectfully submitted,

(Signed) LELAND G. CARLTON
PERCY A. SHAW
E. SHERMAN CHASE, *Chairman*

Committee for Reciprocal Relations with the Institution of Water Engineers

Annual Report of the Legislative Committee

To the New England Water Works Association: The Legislative Committee presents the following report for the year 1941:

In Connecticut a number of radical bills were presented, most of which were defeated in committee. Two are perhaps worthy of mention although neither was enacted. One provided that where a stream is taken over for water supply purposes the utility shall purchase all the water rights upstream from their development which are in any way damaged because of the taking over of the stream for water supply purposes. The other bill provided that no water utilities might make a service charge of any kind.

In Maine, two important acts were passed. The Sabotage Prevention Act is of considerable length and the effect on water utilities may be summarized briefly by saying that it provides for arrest without warrant by guards, and penalties, for persons entering upon water works property without permission, provided that such property is posted as specified with signs reading "No Entry Without Permission". Provision is also made for closing or restricting the use of highways where use may endanger public utilities. Another act, which was passed, was entitled "An Act to Assist Rural Sanitation Activities", but in effect it cancelled most of twenty years progress in plumbing sanitation by relieving from inspection the plumbing in private dwellings not connected with public water or sewerage systems. A third important act was defeated. This would have made taxable all properties of Public Municipal Corporations wherever they were located, that is, whether within or without the corporate limits.

In Massachusetts, three bills of interest were defeated in committee. One would have prohibited shutting off the water or reducing the pressure for non-payment of water bills. Another bill would have required the Department of Safety to make regulations for the operation of stationary, internal-combustion engines of over fifty horse power. Another would have prohibited posting of water supply property by the Metropolitan District Commission against hunting and fishing except within one-half mile from intakes.

Among the bills enacted in Massachusetts, one, effective immediately, made several changes in the lien law. This was House Bill No. 1105, redrafted and passed as House No. 2512. We have no

copy of the final draft, but in the original it was provided that a charge of one dollar should be added for preparing and filing the lien and changes made in the procedure by the assessors in committing to the tax collector. Another bill provided for the extension of the contributory retirement system so that employees of water districts may be included, and another authorized the Department of Public Health to regulate pollution and contamination of inland and tidal waters.

Respectfully submitted,

(Signed) SIDNEY S. ANTHONY
JAMES J. DILLON
LEON A. GOODALE
HAROLD W. GRISWOLD
GEORGE A. REED
PERCY R. SANDERS
STEPHEN H. TAYLOR
ARTHUR C. KING, *Chairman*

Annual Report of the Committee on Committees

This Committee was appointed by the Executive Committee of the Association, to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable.

Appointment of Committees

Your Committee, in its 1940 report, recommended an amendment of the Constitution to provide for a more effective method of committee appointments. This recommendation was adopted and the following amendment to the Constitution was presented to the membership by the Executive Committee and accepted:

"A a meeting of the Executive Committee to be held in October of each year, the Executive Committee of the Association shall appoint the members of all standing professional and technical committees of the Association or shall delegate the duty of appointing any or all of such committees to the President, except as otherwise provided in the Constitution. A list of all such committee members shall be forwarded to each committee member by the Secretary in November. In case such appointments are made by the President, he shall notify the Secretary of his appointments on or before the first week in November. During the month of November the Secretary shall send a list of committee members to the Editor of the JOURNAL, who shall arrange for its publication in the December issue of the JOURNAL. Interim committee appointments shall be made by the Executive Committee or as otherwise directed by vote of the Association and notification of such committee members shall be made by the Secretary within fifteen days after their appointment."

In the future it is believed this will permit better functioning of committees during each year, doing away with former delays.

Present Standing Committees

During the year, President Carlton appointed the following committees: Committee on Sabotage, Committee on the Tentative Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs (Joint Committee with the A.W.W.A. and A.W.S.) and Committee on Revision of the Constitution. Your Committee during the present year addressed a letter to the chairmen of the committees mentioned and of the other standing technical and professional committees which were continued by the vote of the Executive Committee. Returns have been received from almost all of the committees and comments are made below regarding committee activities, with recom-

mendations for future continuance or discontinuance, based largely on the recommendations of the various committee chairmen.

Committee on New Members. This committee is active and contains representation from each of the New England states.

Committee on Finance. This committee is appointed by the Executive Committee annually in November, according to the Constitution, which also sets forth the duties of the committee in preparation of a budget.

Committee on Technical Program. This committee is an active key committee.

Committee on Coefficients of Friction in Pipe Lines. No new developments are reported, but it is expected that a final report may be made in the near future, such report to be made jointly with a committee of the American Water Works Association on the same subject. This committee should be continued.

Committee on Specifications for Cast Iron Pipe and Special Castings. No new developments are reported, but the committee expects to make a progress report and should be continued.

Committee on Standardization of Pipe Flanges and Fittings. No new developments are reported, but the committee expects to make a progress report and should be continued.

Committee on Water Works Education. This committee is active and should be continued.

Committee to Investigate Grounding of Currents on House Plumbing. No new developments are reported, but the committee should be continued. It is likely that the American Research Committee on Grounding of which the New England Water Works Association is an active member will eventually have some interesting conclusions to report.

Committee on Sanitary Hazards of Interior Piping, Fixtures and Water Storage Within Buildings. This committee was continued to coöperate with a similar committee of the American Water Works Association. No new developments are reported. As the present committee chairman has expressed himself as desirous of being relieved of his duties and also doubts the need for present continuance of the committee, it is recommended that this committee be discontinued for the present.

Committee on Hydrant Specifications. This committee has

worked jointly with the American Water Works Association. The American Water Works Association reports that certain discussions are now being carried on with reference to the specifications for fire hydrants. These discussions relate to the interpretation of Section 3.11 of the hydrant specifications. Possibly an explanatory footnote may be added to the specifications. It appears desirable to continue this committee for the present.

Committee on Meter Specifications. This committee is active and expects to present a progress report in 1941. It should be continued.

Committee on Emergency Procedures. This committee made a comprehensive report in 1940 which was presented as a preliminary report. The Association published this in pamphlet form. It is recommended that the committee be asked by the Executive Committee to review this report after which it might well be presented as a final report to the Association for final acceptance and publication in the JOURNAL. It seems very desirable to have this valuable committee report in the JOURNAL.

Committee on Rainfall and Yield of Drainage Areas. This committee is active and expects to submit a progress report in 1941. The committee should be continued.

Committee on Water Quality Tolerances for Industrial Uses. This committee is active and is gradually accumulating information on which to base a subsequent report. The committee should be continued.

Committee on Library. This committee is active and should be continued.

Publicity Committee. The committee chairman suggests that the committee be revamped or that this work be taken over by the Secretary. It is recommended that the important subject of transmitting information to the general public about the water supply profession through notices of meetings, reports, and other timely matters of interest be considered by the Executive Committee.

Legislative Committee. This committee expects to submit a report in 1941. The committee is active and should be continued.

Committee on Reciprocal Relations with the Institution of Water Engineers (England). This committee expects to submit a report in 1941. The committee is active and should be continued.

Committee on Survey of Ground Water Supplies in New England. This committe expects in 1941 to submit a report with statistical data

on ground water supplies in New England. Later the committee is considering a study of well construction specifications. This committee is active and should be continued.

Committee on Sabotage. This committee was appointed to report to the Association on any cases of sabotage or related information in this field. This committee is active and should be continued. If a committee on defense or national preparedness is appointed, as recommended later in this report, it might be well to allocate the work of the committee on sabotage to the committee on defense or national preparedness so as to avoid duplication.

Committee on Tentative Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs. This committee was appointed to consider the acceptance by the Association, of specifications prepared by a joint committee of the American Water Works Association and the American Welding Society. It is expected that a final report will be made in 1941, in which case the committee may be discharged.

Committee to Revise the Constitution. This committee expects to make a final report in 1941 after which it may be discharged.

Sectional Committee on Code for Pressure Piping. The Committee reports that at the present time the code for pressure piping does not include piping for waterworks purposes but that in case water piping should be included in the Code, the New England Water Works Association should be represented on the Committee. It is recommended that this committee be continued for the present to watch further developments.

Committee on Committees. This is the name of the committee submitting this report and its continuance is recommended.

New Committees

Defense or National Preparedness. There is perhaps some tendency for over-organization along defense lines resulting in needless duplication of effort. Defense committees have been appointed by such organizations as the American Water Works Association, the American Society of Civil Engineers and countless local groups, many of whom are studying water works defense activities. It would seem that much of the active defense work in the water works field can best be organized by states, tying in with state departments of health, state public utilities commissions, etc. In the New England area some state committees have already been formed and are very active.

It is suggested that the best approach to this question by the New England Water Works Association would be for the Association to get in touch with state health departments and Association members in each New England state to determine whether water works defense committees have been appointed, and possibly to promote the appointment of such committees where none exist. It would then appear that the Association might appoint a committee to consist of one member from each state committee so as to afford a means of providing mutual assistance and keeping the Association membership as a whole acquainted with developments. The Association committee under such a plan would be a clearing house for dissemination of general information rather than an active organizer of defense activities. This would be in contrast to the state committee activities and would not create unnecessary duplication.

Water Quality. In its 1940 report this Committee suggested that in view of a contemplated revision of standards of water quality by the United States Public Health Service, consideration might be given by the Association to the appointment of a committee on this subject. No committee was appointed, but the United States Public Health Service did appoint an advisory committee consisting of representatives of a number of national associations but not the New England Water Works Association. A recommendation has been made to the United States Public Health Service by the President of this Association that an appointment to this advisory committee be made from the Association. If the United States Public Health Service does not accede to this request, it is nevertheless recommended that a committee be appointed by the Association to keep in touch with recommendations as to changes in the standards of water quality for interstate carriers. These standards have national recognition and their promulgation is of the greatest importance to water works and public health officials.

Sluice Gates. The Secretary of the American Water Works Association, in a communication to the Association Secretary under date of August 28, 1941, states that the American Water Works Association has now in the process of printing a final report on specifications for sluice gates and would welcome consideration and possible approval of these specifications by the New England Water Works Association. It is recommended that a committee on sluice gates be appointed.

Survival and Retirement Experience with Water Works Facilities.

The American Water Works Association has invited the New England Water Works Association to participate in the study of this subject, but no action has yet been taken by the Association. It is recommended that this invitation be accepted. In any case, the American Water Works Association should be advised as to the position of the Association.

Your Committee repeats its recommendations in the 1940 report relative to the establishment of committees on the following:

Research. Your Committee feels that the possibility of the Association coöperating with various technical institutions in the New England area on research problems in the water works field should not be lost sight of. A committee on this subject containing representatives of these institutions might work out a worth while program. Financial assistance from the Association should be made possible if deemed advisable.

Cathodic Protection of Steel Tanks and Standpipes. This form of protection of steel tanks and standpipes is meeting increased interest. It is recommended that consideration be given to the appointment of a committee to report on this subject to the Association. Attention should be given to the possible adverse effects from use of inferior equipment and the question of sanitary protection of water quality during and after installation of equipment.

Corrosion and Remedial Measures. This subject is of interest to all water works engineers and superintendents. The formation of a committee to report on this subject has been discussed in the past. Even if such a committee confined its activities to an annual review of new developments in the field, its work would be of value.

Recommendations

1. That existing committees be continued as discussed in this report.
2. That the committee on sanitary hazards of interior piping, fixtures and water storage within buildings be discharged, as requested by the chairman, with due consideration of the possible desirability of reviving this committee in the future.
3. That the committee on emergency procedures be asked to review its preliminary report and submit a final report with a view to its acceptance and publication in the JOURNAL.

4. That the Association investigate and support the formation of water works defense committees in each state in the New England area with a view to appointment of an Association committee on water works defense to be made up of one representative each from the state committees, such committee to keep the Association membership advised as to developments. This plan would avoid duplication of present efforts.
5. That the work of the publicity committee be extended and better promoted by the Association not only to give the public notice of the activities of the Association but also to carry to the public a better realization of the importance of the water superintendent's job.
6. That the Association consider the advisability of appointment of committees on water quality, sluice gates, survival and retirement experience with water works facilities, research, cathodic protection of steel tanks and standpipes, and corrosion and remedial measures.

Respectfully submitted,

(Signed) WARREN J. SCOTT, *Chairman*
THOMAS R. CAMP
HARRY U. FULLER
ARTHUR C. KING
ARTHUR L. SHAW

APPENDIX

Committees of the New England Water Works Association

Committee on the Award of the Dexter Brackett Memorial Medal for 1941: John R. Baylis, *Chairman,* George A. Sampson, Roger W. Esty.

Finance Committee: Daniel M. Sullivan, *Chairman,* Horace J. Cook, Benjamin H. Keeler.

Technical Program Committee: Joseph C. Knox, *Chairman,* Frederick O. A. Almquist, Sidney S. Anthony, Harold L. Brigham, Gordon M. Fair, George A. Sampson.

Committee on New Members: Harold L. Brigham, *Chairman,* Sidney S. Anthony, George E. Hawkins, Abel Reynolds, Percy R. Sanders, Frederick O. A. Almquist, Clarence I. Sterling.

Sectional Committee on Code for Pressure Piping: Thomas F. Wolfe.

Committee on Coefficients of Friction in Pipe Lines: Elson T. Killam, *Chairman,* Frank A. Barbour, William W. Brush, Charles W. Sherman.

Committee on Specifications for Cast Iron Pipe and Special Castings (Sectional Committee under A.S.A.): William R. Conard, *Chairman,* Arthur L. Shaw.

Committee on Standardization of Pipe Flanges and Fittings (Sectional Committee under A.S.A.): William R. Conard, *Chairman,* Frank A. Barbour.

Committee on Water Works Education: Robert Spurr Weston, *Chairman,* Gordon M. Fair, Percy R. Sanders.

Committee to Investigate Grounding of Currents on House Plumbing (Cooperating with the American Research Committee on Grounding): George A. Sampson, *Chairman,* Warren A. Gentner, Arthur P. Harrington, Edward E. Minor.

Committee on Meter Specifications (Joint Committee with A.W.W.A.): Richard H. Ellis, *Chairman,* Warren A. Gentner, D. H. Hall.

Committee on Rainfall and Yield of Drainage Areas: Arthur D. Weston, *Chairman,* Harold K. Barrows, Richard S. Holmgren, Harvey B. Kinnison, Elbert E. Lochridge, Arthur T. Safford, Caleb M. Saville, Charles W. Sherman, Miner R. Stackpole, James L. Tighe, Paul L. Bean, George V. White, Francis H. Kingsbury.

Committee on Water Quality Tolerances for Industrial Uses: Edward W. Moore, *Chairman,* Stuart E. Coburn, Franklyn J. Lammers, Lewis Olney, Hervey J. Skinner, Robert S. Weston.

Committee on Library: E. Sherman Chase, *Chairman,* Francis H. Kingsbury.

Legislative Committee: Arthur C. King, *Chairman,* Sidney S. Anthony, Theodore L. Bristol, James J. Dillon, Madison H. Goff, George A. Reed, Percy R. Snaders, Stephen H. Taylor.

Committee on Reciprocal Relations with the Institution of Water Engineers (England): E. Sherman Chase, *Chiarman,* Leland G. Carlton, Percy A. Shaw.

Committee for Survey of Ground Water Supplies in New England: Leslie K. Sherman, *Chairman,* Joseph Knox, Howard H. Potter, Walter J. Shea, E. L. Tracy, Leonard Trager.

Committee on Revision of the Constitution: Percy A. Shaw, *Chairman,* Karl R. Kennison, Warren J. Scott.

Committee on Water Works Coöperation in Defense: Arthur D. Weston, *Chairman,* Theodore L. Cate, Harry U. Fuller, G. E. Lourie, Joseph E. Moore, Walter J. Shea.

Committee to Report on the Revision of the U. S. Public Health Service Standards of Water Quality: Arthur D. Weston.

Committee on Sluice Gates: William R. Conard, *Chairman,* Harold W. Griswold.

Committee on Survival and Retirement Experience with Water Works Facilities: Leland G. Carlton, *Chairman,* Harry U. Fuller, Reeves J. Newsom, Arthur V. Ruggles, Thomas H. Wiggin.

Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation: Edward W. Moore.

Committee on Committees: Warren J. Scott, *Chairman,* Thomas R. Camp, Harry U. Fuller, Arthur C. King, Arthur L. Shaw.

Committee on Cathodic Protection of Steel Tanks and Standpipes: Charles W. Sherman, *Chairman,* Donald C. Calderwood, Harry U. Fuller, Madison H. Goff, Samuel E. Killam.

Committee on Hydrant Specifications (Joint Committee with A.W.W.A.): Roger W. Esty, *Chairman,* Harry U. Fuller, Harold W. Griswold.

Annual Report of the Committee on Water Works Education

To the New England Water Works Association:

Gentlemen: Your committee on Water Works Education is pleased to submit its report for the year 1940-1941:

During the year, and on the mornings of the monthly meetings, a course of lectures on hydraulics has been given by George E. Russell, Professor of Hydraulics at the Massachusetts Institute of Technology. They have been continued from month to month with increasing interest in the subject, a most vital one to water works men. These lectures have been informing and practical, as the praise which has followed them has testified. In fact, it has been difficult to relieve the lecturer at the end of the assigned period, and in deference to following meetings.

While your Committee recommends continuing the Water Works School in lecture form, and while it is far from recommending that instruction be confined to one fundamental science, it believes that it is best to start the coming year with lectures on hydraulics provided Professor Russell's services are available.

Few lectures can be given during the meetings of the year, and the subject of hydraulics, even for the general information of laymen, calls for more than a few demonstrations. The continued interest in the subject indicates a desire for more instruction, and because it seems well to have the membership become well informed in one fundamental subject at the time, rather than be just introduced to a succession of subjects, the continuance of lectures in hydraulics seems for the best interest of the Association.

Other bases for this opinion are that the membership changes but slowly, and that matters pertaining to laboratory technique and control are cared for in the Chemists' Section which follows the Water Works School on days of meeting.

Your Committee therefore recommends the continuance of lectures on hydraulics by Professor Russell for a few more meetings at least.

Yours respectfully,

(Signed) Robert Spurr Weston, *Chairman*
Gordon M. Fair
Percy R. Sanders

REPORT OF THE COMMITTEE ON WATER WORKS EMERGENCIES

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LETTER OF TRANSMITTAL

To the New England Water Works Association:

Persuading water works authorities to prepare for disasters or major emergencies is not unlike the task of persuading the average busy individual, enjoying normal health, to prepare his last will and testament—"just in case something should happen."

Planning, preparing, and rehearsing for action when an emergency strikes is too generally looked upon as something that can be done during the first spell of bad weather—in other words, tomorrow. These tomorrows have a habit of turning into todays and "will" never does get prepared—just so runs the World at large, and water works executives are no exception to the rule.

In an attempt to remind water works managers that emergencies do strike, and in an attempt to outline for their benefit some considerations to which thought should be given before the unexpected happens, your Association has set up this Committee on Water Works Emergencies, and charged it with drafting a set of suggestions and recommendations looking toward preparedness for construction, operation, and maintenance during emergency periods.

There are so many types of emergencies that may be experienced in water works operation that it is patently impossible to prescribe so as to cover all types of emergencies. However, there are many considerations that apply to the commoner forms of emergencies, and these your Committee have undertaken to present in this report. If the present report contains any single thought which your Committee most wishes to emphasize, it is that of *preparedness* which can only be realized by answering the question—"If this or that happens, what will I do: first, second, third, and so on?" This question after being answered by the manager himself is one that bears repeating to employees down the line. In short, the important element in *any* emergency is a well defined plan of action (when and how), all without having to think it out over a telephone at 3 a.m., facing a thermometer with its mercury either out of sight or lifting the roof off, as is usual when emergencies corner you. The other important consideration is the class-room drilling of key employees to know at once which "boat" they are to man when the call comes; what orders to give when an excited or untrained crew is turned out; and where to locate the materials required—all while "Hell's-a-poppin'."

In water works practice, we depend a lot on automatic devices and equipment. What is most needed in emergencies is "Automatic Personnel," and this can be had only through the question and answer "shooting" and practice drills to establish who does what, when, and how. In emergencies, questions and hesitation and mis-moves should

be considered in the same category as the tubercles that prevent automatic valves from functioning when their operation is most essential.

Someone has said, in connection with catastrophes or emergencies, that the first thing to do is NOTHING. That may frequently apply also in water service; but the second thing to do is SOMETHING, but making certain that this "something" is the right thing.

The public has little tolerance for leaders who find themselves unprepared to lead, or lacking a dependably functioning organization with requisite equipment when emergencies come. So, it is with the hope of pointing out some thoughts in connection with emergency preparedness that this report is being offered, subject to improvement that may come out of a critical reading by those who have had more experience than the Committee.

Respectfully submitted,

DONALD C. CALDERWOOD, *Chairman*
FREDERICK O. A. ALMQUIST
PERCY C. CHARNOCK
RICHARD H. ELLIS
LINN H. ENSLOW
WILLIAM P. MELLEY
CLARENCE I. STERLING, JR.

PART I—PRE-EMERGENCY SAFEGUARDS

SECTION 1—SOURCE OF SUPPLY

Section 1.1—Adequacy. A survey should be made to determine whether or not the present source of supply possesses a sufficient margin of safety between the estimated yield during an extended dry period and the requirements of the system, including emergency conditions.

Section 1.11—Yield of Wells. The yield of a well supply should be determined from time to time using an approved method, pumping at a definite rate for a certain period of time and noting the drawdown and recovery. See Reference (4).

Section 1.12—Yield of Surface Supplies. The yield of a surface water supply should be known. It can be obtained by several methods. A Committee of this Association has presented one method. See Reference (1).

Section 1.2—Possible Secondary Supplies. Many secondary supplies are unsatisfactory and their use should be avoided, if possible; but the yields of the nearest suitable rivers, lakes, or ponds and the surplus of industrial or other privately owned supplies should be known. Locations of dwellings should be spotted on maps and any sources of possible pollution noted. The quality of the water should be ascertained and the required treatment determined and planned for ahead of actual need. In order that an emergency source may be available for use, a ready means of making a connection between the emergency supply and the gridiron system should be provided. This will avoid costly rush work and hazardous delay when the emergency strikes. Most state departments of health are equipped to advise local water departments in regard to what constitutes a most likely secondary or emergency source of water supply; in any event, since such a secondary source might be considered a part of the permanent supply, it should receive the approval of the state department of health.

Section 1.21—Connections with Adjacent Systems. Where other water systems in adjacent towns are within reasonable distances, the systems should be connected by pipes of adequate size. While the arrangement should be such as to provide proper separation of the two systems, the speed of establishing flow is a consideration. Flow tests should be made to determine the available flow; and topographical studies should determine what areas can be adequately served from neighboring systems and to what extent fire pumpers may be required to boost the pressure. Inasmuch as the benefits to accrue from such connections are of potential value to both systems, it is recommended that no charge be made for such connections.

Section 1.3—Engineering Survey. An engineering survey should be made using the maximum known or probable run-offs to determine possible weaknesses in construction or design of spillways, dams, and like structures. Consideration of such run-offs has demonstrated that dams which had been considered to have sufficient spillway capacity were actually to be considered unsafe. Factors that should be taken into account are ratio of available storage to run-off, spillway capacities, and the failure of potentially dangerous dams upstream. The engineering survey should also include a study of the distribution

mains in order to determine if they can be affected by washouts during floods. See Reference (8).

Section 1.31—Inspection. Dams, spillways, head gates, penstock intakes, flood gates, etc., should be inspected frequently for seepage, condition of masonry, and presence of debris that might clog the spillway and allow the dam to be overtopped during a heavy run-off. Valves and other moving equipment at gate houses should be operated at least once a year and maintained in good working condition.

Section 1.32—Keys. Master keys for all locks for gate houses, chlorinator houses, booster pumping stations, gates, etc., should be provided in sufficient number to allow one for each responsible employee.

Section 2—Pumping Stations

Section 2.1—Location of New Pumping Stations. Pumping stations should be located so as to be above possible flood elevation, removed from exposure to fire, away from possible damage of falling trees, and accessible by road.

Section 2.11—Location of Existing Pumping Stations. Where existing pumping stations are subject to flooding, an engineering study should be made to lay out a program for permanent reconstruction of suitable works that will eliminate the dangers of interruptions of service. The appropriations and construction work can be extended over a period of years to lessen the financial burden. Until such permanent work is completed, temporary provision should be made to hoist motors and equipment above flood water elevation and to barricade and make watertight all windows, doors, and drains or other openings. In this connection, a supply of bags and suitable soil should be made available.

Section 2.2—Equipment. Duplicate equipment should be provided and the capacity of pumping equipment should be such as to meet domestic demands plus fire requirements. Emergency sump pumps should be provided and should be of sufficient capacity to handle expected leakage.

Section 2.3—Source of Power. If electric power is used, it is desirable that the transmission lines be so connected that power may be obtained from more than one source. Duplicate transformer and

transmission lines, with *wide clearances* to reduce the hazard of their simultaneous destruction by fire, falling trees, or underground cables should be given consideration.

Section 2.31—Permanent Emergency Sources of Power. When the sole source of power is electrical energy, emergency sources of power sufficient to operate the major units should be provided including generating equipment, operated by or with direct connection to water wheels, Diesel engines, gasoline engines, or steam equipment. These stand-by units should be properly maintained and operated periodically, at least once a month. Attention is called to the fact that steam generating equipment depreciates rapidly unless it is carefully maintained. Failure in electric power should be considered in connection with failure of lighting facilities, sump pumps, and other equipment as well as the major pumping units. Stand-by arrangements should be made.

Section 2.32—Other Emergency Sources of Power. Numerous types of portable power units are available, such as electric welding and thawing equipment, compressors, and tractors with power take off pulley. Even storage batteries may be used. Priority in the equipment should be assured if it is not owned by the water works.

Section 2.4—Fuel. Fuel storage is necessary, especially for emergency equipment. A sufficient quantity of fuel should be on hand at all times to operate emergency equipment at full capacity for at least five days. If fuel is needed for the manufacture of primary power, it may be necessary to store fuel, particularly when the pumping station is situated in an inaccessible location, to cover long periods of inclement weather. Petroleum products, on being stored for a long time, separate and give trouble. Storage containers or tanks should be so located as not to be affected by floods, properly anchored, and equipped with vents that extend above the high-water line.

Section 3—Treatment Plants

Section 3.1—By-passing. The maximum capacity of a given filter plant should be determined in so far as hydraulic limitations are concerned, because during an emergency it would be preferable to operate filters at higher than designed rates than to by-pass filter units completely. Under ordinary conditions, by-passing of water around a

treatment plant should not be permitted. Where filter plants have been constructed to treat waters that are reasonably safe, a by-pass might be provided in such manner that a permanent cross-connection is not created. On waters that are highly polluted, a by-pass would be potentially dangerous and should be prohibited. By-pass arrangements should be of ample size, and provision should be made to assure a high degree of disinfection when the by-pass is in use. The state board of health should be consulted if a by-pass of this kind is contemplated.

Section 3.2—Source of Chemicals and Supply. An adequate supply of chemicals should be kept in protected, safe storage at all times. If the source of supply is not local, at least one month's supply should be available and, under some conditions, a supply for an even greater length of time may be desirable.

Section 3.21—Other Sources of Chemicals. The various possibilities of obtaining chemicals, chlorine, etc., at short notice should be studied. Adjacent municipalities, industrial plants, or the state health department may be of aid.

Section 3.3—Sources of Power. Sources of power are discussed under sections 2.3, 2.31 and 2.32. In plants in which water is delivered by gravity to the distribution system, the amount of power for miscellaneous uses, such as operating chemical feed machines, hydraulic valves, and lighting, may be fully as essential as the power used for pumping purposes. Failure of this power for miscellaneous uses may cripple a plant, and what to do in case of such failure should be planned in advance.

Section 3.4—Sources of Emergency Equipment. A list of possible sources of emergency equipment, including machines, chlorinators, and filtration equipment should be kept on file. State departments of health usually have portable chlorinating apparatus that is available in case of emergency.

Section 3.5—Chlorination. Because of the importance of chlorination, duplicate chlorinators and parts should be available, and a quick source of additional parts should be known. The operation of chlorinators should not depend on electric power alone. Sufficient chlorine should be available together with a ready source of additional chlorine. The equipment should be inspected daily if in operation. The emergency equipment should be operated at least weekly to assure that it is in good working condition. Chlorinator equipment should include

the means necessary for increasing the chlorine dosage well above that normally used. Portable chlorinators used for the disenfection of mains make excellent emergency equipment. Full cylinders of chlorine should not be stored in the same room with empty cylinders in order that the inventory of full and empty cylinders may not be confused. It is a good idea to keep one full cylinder tucked away but changing it at least every 6 months. Where the gaseous form of chlorine is used, gas masks with proper canisters should be provided and stored in a place accessible at all times. Gas masks should be checked periodically, and the manufacturer's recommendations should be followed explicitly.

Section 3.51—Source of Local Supply of Chlorine. A list of local jobbers should be kept and a supply of one of the high-strength chlorine compounds stocked for emergency use in case the chlorine equipment should fail or prove of inadequate capacity. A dosage chart and home-made equipment should be provided in this event and testing equipment made available. (See appendix for sketch of home-made apparatus).

Section 3.6—Personnel. See Section 7.1.

Section 4—Distribution Storage

Section 4.1—Local Storage. In addition to good storage at the source, it is desirable to provide storage in the distribution system. Such storage allows for continuity of service in the event of breakdown of pumps or failure of supply mains.

Section 4.2—Amount of Storage. The amount of storage should meet requirements of the National Board of Fire Underwriters. These specify that for a break in the source of supply or force main or the break-down of the two largest pumps in a pumping station, there should be a sufficient amount of water in storage so that in connection with other supply or force mains and remaining pumps in service at the end of five days of maximum consumption there would still be available a 10-hour fire supply. In some communities, high-level storage can be obtained only by the use of elevated tanks or standpipes. Where this condition exists, the requirements probably can be met by the installation of additional pumping equipment.

Section 4.3—Location of Storage. The location of storage reservoirs or elevated tanks in the system should be such that maximum benefit is obtained in the form of suitable pressure and adequate quan-

tity. It is desirable that water from storage should enter the distribution system independently of the supply lines from the main sources of supply.

Section 4.4—Construction. The storage reservoir should be constructed properly so as to withstand, or be protected from, floods, earthquakes, winds, or other destructive elements. Today, with the European War and general world unrest, it might be well to consider possible ways to protect open reservoirs against poisoning or bombing.

Section 5—Distribution Piping

Section 5.1—Records of Plans. Duplicate records and plans of all supply works, distribution mains, hydrants, and valves, should be prepared. These should be kept at separate locations; one preferably in a fire-proof vault. Copies should be made available for service trucks or foremen. Most of the larger communities now have adequate plans, but there are many smaller systems that are woefully lacking in accurate construction records. If the plans are now inadequate, it probably is impossible to obtain the missing data immediately, but if the conditions encountered at each point where excavations are made are accurately recorded, much of the missing data will be accumulated over a period of years. See Reference (7).

Section 5.11—Valve Openings. Irregular arrangements should be noted on records such as right- or left-hand opening of valves or other irregularities.

Section 5.12—Location of Valves. Ties for purposes of locating valves or other underground appurtenances should be made to permanent monuments that cannot be easily destroyed or moved. Where available, the location of valves and underground equipment should be tied into a general survey network.

Section 5.13—Operation of Valves and Equipment. Valves or other equipment with movable parts should be operated at least once a year and kept in good working condition by frequent inspection, as safe practice dictates.

Section 5.2—Record of Pressures. Pressure-recording gauges should be provided, preferably at several locations in a distribution system. These are valuable in quickly detecting abnormal conditions in the system. These charts should be inspected daily and filed.

Section 5.3—Installation of Piping. Water mains should be run in separate ditches from sewer or other utility lines.

Section 5.4—Fire Flow Requirements. The requirements of the National Board of Fire Underwriters with regard to fire flows should be met. (See appendix for table of requirement). Hydrant tests should be made periodically and reports kept on file for comparison with future test results. The results of these tests should be supplied to the fire department so that the number of hose streams available from any hydrant or group of hydrants may be known to this department.

Section 5.5—Supply Mains. Duplicate supply mains from duplicate intakes are desirable. Each supply main should be adequate to take care of the entire flow if necessary. Wherever possible, arrangements should be made to supply all parts of the distribution system with flow from two directions.

Section 5.6—River Crossings. Care should be exercised in the construction of lines for river crossings to prevent failure by washout or dragging by ships' anchors, if laid in a trench, or by frost, if laid on a trestle. Duplicate crossings are advocated. Valves should be provided at either side of river crossings sufficiently far removed from the crossing so as to be available in an emergency. Such valves should be carefully maintained and systematically inspected. Large-diameter, reinforced rubber hose is now available for emergency crossings. Hydrants and gate valves located on either side of the crossing will greatly assist in making a temporary connection.

Section 5.7—Cold Weather Troubles. In northern climates a period of extreme cold is occasionally experienced and unless the mains and services are unusually well protected some will freeze. Thawing may be accomplished by steam, hot water, and electricity. After thawing, circulation must be maintained artificially until the frost level in ground rises above the pipe.

Section 5.71—Steam Thawing. In thawing by steam, a portable burner and boiler are used to generate the steam which is conveyed into the pipe to be thawed by a flexible hose or tube. Because steam soon condenses, this method is restricted to comparatively short distances.

Section 5.72—Hot-Water Thawing. This is somewhat similar to thawing by steam inasmuch as the pipe has to be opened and a force pump is used to pump hot water through the flexible block tin or copper tubing that is pushed into the pipe. As the ice melts, the tubing is pushed ahead into the pipe. Much longer distances can be thawed by hot water than by steam.

Section 5.73—Electric Thawing. In thawing by electricity a current is forced to flow through the pipe and the resistance offered produces the heat that thaws a thin film of ice near the metal. The water should be allowed to run full force through the pipe for some time after the film has melted because the flowing water will melt the remaining ice. Currents of 100 to 500 amperes are used depending on the diameter of the pipe. Three methods are used to obtain current with the characteristics satisfactory for pipe thawing, the one to be used depending on local conditions and equipment available. Small portable transformers that tap the regular electric house service are now available, and these usually have sufficient capacity for services and small-sized mains. The electric power company can mount transformers on trucks and tap the high-tension lines. This is usually necessary when large diameter mains are frozen. The third method employs a portable, electric welding-machine. This is a mobile, self-contained unit and constitutes a decided advantage over the other two methods. Several excellent articles have been published on thawing. See Reference (5).

Section 5.74—Bleeding Mains and Services. After frozen pipes have been thawed or when frost penetrates to the level of the pipe, circulation must be maintained 24 hours a day to prevent freezing. On house services, this is easily accomplished by cutting a "V" shaped notch in the packing of any cold-water faucet and allowing the water to run into the sewer. Where there is a house at the end of the main, this method will also give protection to the main pipe, but larger quantities should be wasted. Another method is to open blow-offs at stream crossings or into sewers. If no other method is available, a new tap into the main may be necessary.

Section 5.75—Predicting Frost Penetration. Studies have been made showing the relationship between temperature deficiency and frost penetration. By keeping an annual temperature deficiency curve and comparing it with previous years when trouble from freezing was experienced, prediction can be made with considerable accuracy when trouble can be expected, and by artificial circulation freezing can be prevented. See Reference (6).

Section 5.8—Disinfection of Pipe Lines. All new mains or repaired existing mains or pipelines should be disinfected with chlorine using a rate of dosage of 50 p.p.m. See Reference (3).

Section 6—Proper Construction of Distribution Systems

Section 6.1—Approved Practice. That approved practice, so far as materials and strength are concerned, should be followed in the construction of a system goes without saying.

Section 6.11—Laying of Pipes. Reference is made to the Tentative Standard Specifications of the American Water Works Association, for Laying Cast Iron Pipe. See Reference (3).

Section 6.12—Construction Planning. Reference is made to "Preparedness Plan for San Francisco," Reference (2).

Section 7—Training of Personnel

Section 7.1—Personnel. Sufficiently well-trained personnel should be provided to operate pumping stations and water-treatment plants and to perform other operating duties. More than one person should be capable of fulfilling the duties of even the lowest positions. The personnel should be trained and a plan worked out whereby in an emergency each employee automatically performs a certain duty without notification. This is necessary because of possible failure of communication systems. Practice sessions should be held from time to time. Such a plan is described in Reference (2). The addresses and telephone numbers of personnel should be listed. In modern practice, trucks and headquarters equipped for two-way radio represent a development worthy of note. The possibility of strikes or other labor troubles should be considered.

Section 8—Emergency Equipment

Section 8.1—List of Possible Emergency Equipment. A list of all emergency equipment that may be drawn upon, pumps, trucks, and other material, should be made and posted together with the location of each piece, and periodic checks should be made to assure that the equipment is there and in working condition.

PART II—EMERGENCY ADMINISTRATION MEASURES

Section 9—Local Coordinating Committee

Section 9.1—Membership. A permanent committee headed by the mayor or chairman of the selectmen should be organized to include the persons or representatives selected from the organizations listed in

subsequent paragraphs of this section. In addition to those mentioned, all individuals or organizations that could be of assistance should be included. The local committee should contact and work in conjunction with a similar state committee that has been formed.

Section 9.11—Law and Order.

a. Chief of Police,
b. Nearest State Police headquarters,
c. Commander of local National or State Guard,
d. American Legion.

Section 9.12—Fire and Rescue.

a. Chief of Fire Department,
b. Hospitals,
c. Ambulance service,
d. Welfare Department,
e. Salvation Army.

Section 9.13—Utilities.

a. Water Company,
b. Gas Company,
c. Electric Company.

Section 9.14—Transportation.

a. Railroad and bus companies,
b. Motor truck companies,
c. Auto Club,
d. Taxi companies,
e. Local airport.

Section 9.15—Communications.

a. Telephone and telegraph companies,
b. Radio Station,
c. Radio club (short wave),
d. Boy Scouts.

Section 9.16—Health and Sanitation.

a. State Department of Health,
b. Local Health Department.

Section 9.17—Public Works.

a. Local Department of Public Works,
b. State Department of Public Works.

Section 9.18—Weather Bureau

Section 9.19—Voluntary Service Organizations.

a. Red Cross,
b. Chamber of Commerce,
c. Rotary Club,
d. Kiwanis,
e. Lions,
f. Other civic clubs.

Section 9.2—Organization. The chief executive of the community should be the permanent chairman. The actual organization will be more or less controlled by local conditions. Hartford, Connecticut, and Boston and Springfield, Massachusetts, have excellent plans worked out which could be used as a guide.

Section 9.21—Listings. The names and telephone numbers of the entire organization and committee appointees should be published and kept up to date. Copies of this list should be posted at permanent general headquarters and given to every member.

Section 9.22—General Alarm. In planning for a general emergency, a special signal on the fire alarm or radio can be assigned to bring committee members to previously assigned key stations or to the general headquarters. Sometimes it may be necessary to have the police or firemen contact key officials. Drills should be held to train the personnel in their duties.

Section 9.3—Assistance from Outside Sources. This is covered in part by Section 9.1, but it should also include reciprocal working agreements with similar committees in neighboring cities and state governmental agencies.

Section 10—Use of Emergency Sources of Supply

Section 10.1—Failure of Public Supply. When the public supply fails, another supply, if available, must be pressed into service. Before this secondary supply is used, its safety should be passed on by a capable authority, usually a representative of the state health department. Many states have a regulation requiring the water department to notify the state health department immediately if the treatment of a public water supply is interrupted or the source of supply is damaged so as to impair, or to be likely to impair, the quality or the sufficiency of the supply. This is an excellent regulation and should be followed to the letter.

Better yet is the plan of advance notification of the authorities if an emergency appears to be impending. In any event, the local health authorities should be notified and consulted.

Section 10.11—Abandoning Pumping Stations, etc. Any equipment subject to damage by floods, such as electric motors, switches, transformers, and reduction gears, should be removed and placed above high water if possible. It is desirable to have cranes available to assist in such removals. If a steam pump is abandoned, the valves should be left in such a way as to cause the least possible delay in putting the pumps back into operation. If there is danger of freezing, further care should be taken to drain, so far as possible, water from within the pumping station. This applies also to filter plants. A definite plan should be prepared in advance, and a listing of just what should be done and the procedure to be followed should be posted in each station or plant.

Section 10.2—Emergency Sources. In utilizing emergency sources, disinfection is usually required, and much valuable time will be saved if permanent connections are made for the connection of disinfection apparatus in anticipation of an emergency. See Appendix and Section 3.5 for detailed information regarding emergency disinfection apparatus. Over-disinfection is a good fault during emergencies. Therefore, excess capacity of equipment is a commendable fault.

Section 10.21—Connection to Neighboring Systems. See Section 1.21.

Section 10.22—Ice Ponds. Ice ponds are usually checked as to sources of pollution before ice is harvested. As a rule they are good sources of emergency supplies. These ponds are likely to be limited in capacity, but they are often sufficiently large to last until the regular supply can be put back in operating condition.

Section 10.23—Factory Supplies. Factory supplies should not be used except as a last resort and then primarily to maintain fire protection. Since these supplies are usually non-potable and dangerous, permission of the state health department should be secured and all customers notified BEFORE using such supplies. The actual work should be supervised by a representative of the state health department, and, if possible, a fire underwriter representative.

Section 10.24—Infiltration. Infiltration wells are sometimes used as sources of supply or surface flooding is sometimes practiced to

increase the yield of wells or infiltration galleries. Under abnormal conditions, such supplies may be flooded, and as there is danger of short-circuiting the surface water along the sides of well casings or blow holes in the ground, such supplies should always be chlorinated.

Section 11—Transportation of Water

Section 11.1—Watering Carts. Sometimes, it is necessary to transport water by tanks or watering carts. These carts should be disinfected with a hypochlorite solution using dosage of at least 50 p.p.m. of available chlorine or 0.42 lb. per 1000 gal. To find the pounds of the compound to be added to each 1000 gal. of water, divide 42 by the per cent of chlorine in the compound.

Section 11.2—Gasoline and Oil Tank Trucks. These should be prepared for use in the following manner:

1. Steam, with low pressure steam for 15 to 20 minutes.
2. Scrub thoroughly with a high-pressure hot-water steam jet. Hot water and steam should be furnished by a "Hi-pressure Jenny." (This type of equipment is often used for cleaning building exteriors.)
3. Fill to overflowing with city water and drain off through the tank lines.
4. Fill to within 6 in. of the top with city water to which 2 ounces of chloride of lime (25% available chlorine) have been added for each 1000 gal. of tank capacity.
5. Permit the chloride of lime to remain in the tank for the first 100 miles of travel of the truck at which time all but 200 gal. should be drained off. The 200 gal. should be allowed to remain in the tank until the trucks have reached their destination.
6. Drain the tanks and flush them thoroughly with a fire hose. They should then be ready for the service of hauling drinking water.

Section 11.3—Milk Tank Trucks. These trucks are now being used by many dairy companies for the transportation of milk and, if available, can be used without special preparation.

Section 11.4—Assistance From State Department. National or State Guard, Public Works, Highway, and Conservation departments have tank trucks that may be available. In addition the National or State Guard has Lister bags and mobile water filtration plants.

Section 11.5—Spring Water Tank Wagons. In some communities, there is a demand for spring water that is delivered in large

carboys. Where available, these tank wagons make excellent conveyances for water without delay and uncertainty of disinfection.

Section 11.6—Small Containers. Milk cans of 8-, 20- and 40-quart capacity, are most likely to be available and used for this service. All such containers should first be disinfected by flushing them and then rinsing or allowing them to stand for several minutes in a strong chlorine solution. A chlorine solution containing 100 p.p.m. of available chlorine is satisfactory for this use. It can be prepared by dissolving 0.2 oz. (about 2½ teaspoonsful) of high-strength (70%) chlorine compound in 10 gal. of water. All containers should be properly covered.

Section 11.7—Collection. The collection of water at the source or loading point must be carefully supervised. Water normally potable can easily be polluted in collection and nullify other precautions. It is good practice to chlorinate each tankful of water in such a way that a chlorine residual of 0.2 p.p.m. is maintained after a 10-minute contact period.

Section 12—Power Interruption

Section 12.1—Auxiliary Power of Pumping Plants. This is covered in Sections 2.3, 2.31, and 2.32. The use of welding equipment, nearby factory power, or other sources of power sometimes can be arranged for, but great care must be taken to check voltage and other current characteristics. The reliability of this secondary source of power should be thoroughly investigated.

Section 12.2—Fire Department Pumper. These pumping units are excellent auxiliary units, as they are mobile, self-contained, capable of pumping against high heads, and of relatively large capacity. Water so pumped should be chlorinated at the suction side of the pumper. Caution should be used so that the fire department is not stripped of its fire apparatus and, if necessary, arrangements should be made to procure pumping engines from some other community that can possibly better afford to lend some of its apparatus.

Section 12.3—Portable Pumps. If an auxiliary portable pump is to be used, it must be capable of pumping against high heads, and connections should be provided before the emergency to eliminate delay as much as possible. Low-cost, portable pumping units are now available, and water works may well invest in one or more of these units.

Section 13—Segregating Portions of Distributing System

It is desirable to maintain pressure in the pipe lines during an emergency in so far as possible in order to prevent back-siphonage. However, the leakage from broken services, hydrants, etc., may be so great that segregating or shutting off a portion of the distribution system may be advisable. Key maps of the distribution system based on natural division lines with the gates to be closed marked with suitable symbols will be of great assistance at the actual time of emergency.

Section 14—Quality of Water

Section 14.1—Bacterial Analyses. Bacterial analyses should be made on all waters used for domestic and drinking purposes. However, at times of emergency, time may not permit making the necessary tests. A notice to boil the water and a heavy chlorine dosage should suffice until tests can be completed. Occasional chemical and bacterial examinations of possible emergency supplies, made prior to the emergency, are an excellent indication of what to expect and will suggest the probable treatment needed at the time of actual emergency. State, local, or private laboratories may be used to make these examinations, and each water department should keep a list of all laboratories in the area that possess the equipment and trained personnel capable of making the required tests.

Section 14.2—Other Procedures. Whenever bacterial analyses cannot be performed, the water should be strongly chlorinated and tests for residual chlorine made frequently. A residual of 5 p.p.m. following a 10-minute detention period should be maintained unless advised otherwise by a competent authority. Normally this residual should easily be discerned through taste.

Section 14.3—Pressures. Pressures in systems should be watched closely with a view to being forewarned of possible back-siphonage especially in upper stories of buildings. Permanent installations of pressure gauges in various sections of the community can be watched for possible drops in water pressure. Fire stations and school buildings make excellent locations for such installations.

In the event that water pressure fails completely when water is turned back into the system, the water should be heavily chlorinated at the source to show a residual test of at least 5 p.p.m. in order to

sterilize the water in mains that may possibly have been polluted by back-siphonage.

Section 14.4—Tests for Chlorine Residual. These tests should be made at least hourly when any emergency supply is being used. Care should be taken to insure that the obtained residual is not due to manganese in the emergency supply. The color standards and the orthotolidin solution used in testing for residuals should be checked frequently.

Section 15—Emergency Notice to Boil Water

Section 15.1—When Boiling Order Should Be Issued. When the safety of the supply is in question, it is better to err on the side of safety and issue notices to boil all water used for drinking and domestic purposes. It should be borne in mind that in disastrous emergencies the morale of the population is weakened by ill-considered advice to boil water when there is no danger. If the emergency requires that boiling notices be issued as a precautionary measure, they should be withdrawn as soon as feasible, although it may be necessary to await the results of sampling and analyzing the supply before such withdrawal is officially announced.

Section 15.2—Authority. Notices should be issued by the health authorities usually through the local health officers after consultation with a responsible water works official or the state department of health.

Section 15.3—Method of Notification. When it has been decided to issue boiling notices, every possible means should be used to inform the people. The press, theaters, radio announcements, telephone, and printed notices delivered in person to all consumers are only a few of the more important methods. In delivering printed notices in the absence of consumers, the notice should be tacked to both the front and rear doors, and the house should be visited as soon as possible to make personal delivery.

Section 16—Emergency Disinfection

Section 16.1—Public Supplies. This section is covered in Section 3.5 and in the Appendix.

Section 16.2—Private Dug Well Supplies. These supplies may be chlorinated by a private individual but preferably under the super-

vision of a trained person. Most wells can be thoroughly disinfected by adding about 2 cans of chloride of lime, 25% to 33% of available chlorine by weight or an equivalent amount of chlorine from other chlorine compounds or a solution of chlorine bleach. Chlorine compounds should be dissolved in a pail of water before being poured into the well. The chlorine should stand in contact with the well water for several hours, following which the water can be pumped out to eliminate the chlorine taste.

Section 17—Treatment of Line Breaks

Section 17.1—Minor Breaks. If the break is not serious and the escaping water is not causing too much damage, the water pressure should be maintained.

Section 17.2—Serious Breaks. When the break is serious, the section will have to be shut down and the break repaired. In many cases, the actual repair may take considerable time and it may be possible to bypass the break by laying a temporary line. One or more lines of fire hose stretched between hydrants make an excellent line of this type.

Section 17.21—Ground Water in Trenches. Ground water seeping into trenches may be seriously polluted by sewage, and special care should be taken to de-water trenches to a point below mains that are being repaired or constructed.

Section 17.3—Disinfection. Before turning water into the portion of the system shut down for repairs, it should be disinfected with chlorine using a dose of 50 p.p.m. of available chlorine.

Section 18—Aid Available to Other Organizations

Section 18.1—Water Department Coöperation. The types of disasters and emergencies are many and, in most cases, the water supply will be affected only in some indirect way. Where the water supply is affected only indirectly, the organized personnel and equipment of the water department should be made available to other services. In some communities it is possible to prepare a list of all available equipment that might be of service and to establish a list of priority rights.

PART III—POST EMERGENCY MEASURES

SECTION 19—RETURN TO NORMAL

Section 19.1—Indications. The indications of a return to normal after an emergency will undoubtedly be quite obvious, even though gradual. All equipment and physical features should be thoroughly checked to see if they are in proper operating condition and that all damage has been repaired. If a flood caused the emergency, all valves in the flooded area should be located and tested to ascertain whether or not they are in good working order. All temporary construction executed during the emergency should be replaced by that of a permanent nature.

Section 19.2—Notices of Resumption of Service. If a section of the system has been without water, consumers should be notified that the water is to be turned on. At the same time they should be given instructions to flush all fixtures during a certain period while heavy disinfection is being applied. Boiling of the water may be required in some instances. Water should not be used for domestic purposes until cleared by the results of bacterial examinations.

Section 19.3—Records. In order not to lose the experience gained during an emergency, a complete history of departmental activities should be written at once. It should include all procedures, occurrences, analyses, and the results of each. A frank discussion of the case, pointing out the deficiencies of the system, steps taken to offset these deficiencies, and comments on errors made during the emergency should also be included.

Section 19.4—Recommendations. Practically any emergency will bring to light weaknesses or deficiencies in the system. These should all be listed and studied so that steps may be taken to correct or eliminate them as soon as possible. In this, the aid of a consulting engineer is not to be overlooked, the value of which has been amply demonstrated in connection with planned betterments found advisable in stricken communities.

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APPENDIX

FIRE FLOWS REQUIRED, FOR TOWNS OF VARIOUS SIZES, BY THE NATIONAL BOARD OF FIRE UNDERWRITERS

Population	Required Fire Flow for Average City—g.p.m.	Population	Required Fire Flow for Average City—g.p.m.
1,000	1,000	28,000	5,000
2,000	1,500	40,000	6,000
4,000	2,000	60,000	7,000
6,000	2,500	80,000	8,000
10,000	3,000	100,000	9,000
13,000	3,500	125,000	10,000
17,000	4,000	150,000	11,000
22,000	4,500	200,000	12,000

Over 200,000 population, 12,000 g.p.m., with 2,000 to 8,000 g.p.m. additional for second fire.

In residential districts the required fire flow depends upon the character and congestion of the buildings. Sections where buildings

are small and of low height and about one third of the lots are built upon, require not less than 500 g.p.m.; with larger and higher buildings up to 1000 g.p.m. is required, and where the district is closely built, or the buildings approach the dimensions of hotels or high value residences, 1,500 to 3,000 g.p.m. is required, with up to 6,000 g.p.m. in densely built sections of three story buildings.

Disinfection of Water Mains

The inside of all water mains and special castings, before laying, should be thoroughly cleaned by brushing, swabbing or washing out dirt and loose material. Before being placed in service, all new work should be treated with chlorine sufficient to yield a residual of at least 2.0 p.p.m. after a contact period of 12 hours. The mains should then be flushed until the water runs clear and has no odor of chlorine. If possible, a report of the bacterial examination of the water from the main should be obtained before the main is placed in service. Mains may be disinfected by placing a chlorine compound in the pipe as it is being laid, by pumping a solution of chlorine into the main, or by the use of a solution-feed chlorinator designed to use liquid chlorine.

In general, the amount of chlorine compound should be selected

Table 1—Amount of Chlorine of Various Chlorine Compounds Required per 100 Feet of Main to Provide a Dosage of 50 Parts per Million of Available Chlorine*

Size of Pipe—Inches	Chlorine 100% available		Compounds of High Chlorine Content		Chloride of Lime		Commercial Solutions	
	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Quarts	Pints
4	—	½	—	1	—	2	—	½
6	—	1	—	2	—	4	—	1
8	—	2	—	3	—	7	—	1
10	—	3	—	4	—	11	1	—
12	—	4	—	6	1	—	1	—
16	—	7	—	11	1	12	2	—
18	—	9	—	14	2	3	2	1
20	—	11	1	1	2	12	3	1
24	1	—	1	8	3	15	4	—

*From circular letter of the Massachusetts Department of Public Health on disinfection of water mains, dated March 12, 1940.

to give a dose of 50 p.p.m. of available chlorine. In computing the amount of chlorine necessary, the available chlorine of commercial compounds may be taken as follows:

		Per cent of available chlorine
1.	Liquid Chlorine	100
2.	Compounds of high chlorine content	65-75
3.	Ordinary chloride of lime	25
4.	Commercial chlorine solutions	10

Private Drinking Water Supplies

Chlorination in Connection with Water and Wells Subject to Pollution from Floods

Disinfection of Drinking Water. Where wells are or have been submerged and no safe water supply is available, all water used from such wells should be boiled briskly for 20 minutes or disinfected according to any of the following formula:

1. Ordinary Chloride of Lime (20% to 25% Available Chlorine). Prepare a solution using one level teaspoon of the powder to one quart of water. One teaspoon of this solution to each gallon of water should give about 1.0 p.p.m of available chlorine, which should be sufficient for adequate disinfection.

2. Chlorine Compounds with Large Chlorine Content (60% to 75% Available Chlorine). Prepare a solution by using one level teaspoon of the powder to one quart of water. One teaspoon of this solution to each 2½ gallons of water should give 1.0 p.p.m. of available chlorine.

3. Commercial Chlorine Solutions (6% to 10% Available Chlorine). Prepare a solution by using one teaspoon of the solution to one quart of water. Three teaspoons of this solution to each gallon of water should give about 1.0 p.p.m. of available chlorine.

Disinfection of Wells. Where wells are not exposed to local pollution except from recent flooding and where flood waters have receded, the following procedure may be used:

1. Add ten times the amount of disinfectant recommended for the disinfection of drinking water. Stir and let settle.

2. Add one teaspoon of this settled solution for each gallon of

water in the well, mix with the water in the well and wash down the sides of the well by using a pail on a rope or other means. After ½ hour the well should be pumped out until the odor of chlorine in the water has disappeared.

TABLE 2.—CAPACITY OF WELLS IN GALLONS FOR EACH FOOT IN DEPTH OF WATER

Diameter of Well		Depth—Gallons
Feet	Inches	
—	1	0.04
—	2	0.16
—	2½	0.26
—	3	0.37
—	6	1.47
—	8	2.61
—	10	4.08
—	12	5.88
2	—	23.50
2½	—	36.72
3	—	52.88
3½	—	71.97
4	—	94.00
4½	—	118.97
5	—	146.88
6	—	211.51
7	—	287.88
8	—	376.01
9	—	475.89
10	—	587.52

HOME-MADE CHLORINATION APPARATUS FOR EMERGENCY USE*

A practical and readily constructed solution feeder consists of a wooden barrel or solution tank, a delivery hose and float, and a discharge cock or control valve. See Fig. 1.

The upper end of the delivery hose is attached to the float so that it is under a constant head. The lower end is connected to the discharge fixture. Variations in feed rates may be obtained by inserting glass orifice tubes of different size in the hose influent or by varying the position of the orifice in relation to the float. These feeders are best suited for feeding a chlorine solution into open conduits or suction wells. By using a constant-level, receiving tank they can be used to apply chlorine to a pump suction. See Fig. 2.

*Material on home-made chlorinator apparatus is taken from booklet published by and reprinted with the permission of the Pennsylvania Salt Mfg. Co. and the Mathieson Alkali Works.

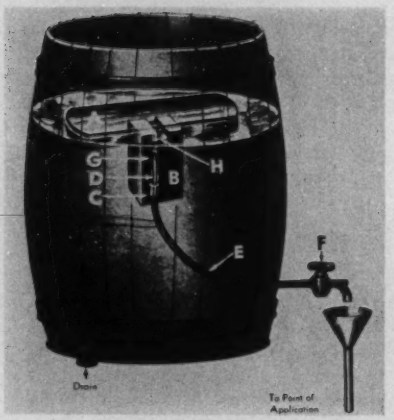

FIG. 1.—FLOATING ORIFICE FEEDER
A 2-in. by 12 in. board of such a length as to float freely.

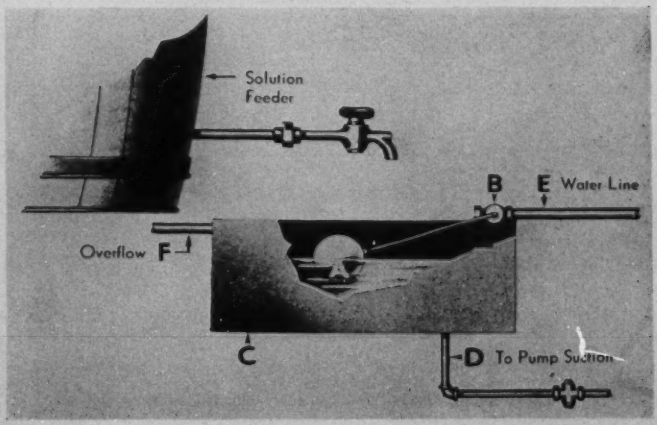

FIG. 2.—PUMP SUCTION FEED DIAGRAM

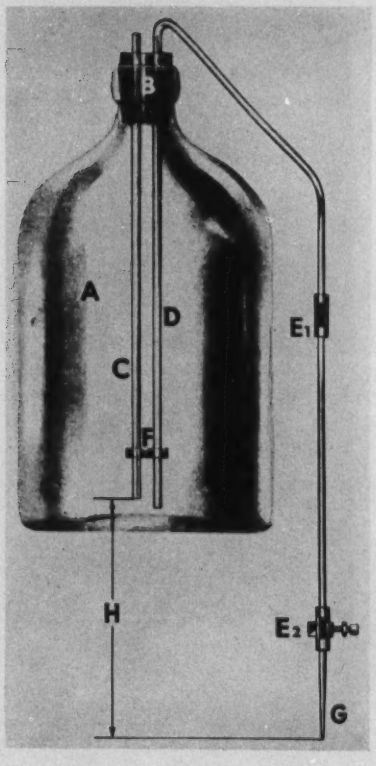

FIG. 3.—CARBOY SOLUTION FEEDER

Construction and Operation

A may be any glass carboy of from 1 to 12 gallon capacity.

B is a tight-fitting 2-hole rubber stopper.

C is a glass breather tube for admitting air. The lower end should be slightly above the end of the siphon tube.

D is a glass siphon tube with rubber hose connections at "E_1" for adjusting the siphon leg and "E_2" for connecting the calibrated orifice tube. (Hose may be fitted with a clamp for shutting off flow).

F is a separator for spacing and holding the tubes together.

G is a calibrated orifice made by fusing or drawing glass tubing. Dosage may be varied by changing the concentration of solution, by altering the head "H" or by using different sizes of orifices. A gaged carboy aids in calibrating. Accurate flows as low as 1 g.p.d. may be obtained.

The receiving tank should be equipped with a ¾-in. water-supply line terminating in a float-controlled valve. A ½-in. hard-rubber line fitted with a hard-rubber cock should extend from the receiving tank to the pump-suction pipe. The feeder may discharge directly into the tank or into a gravity hose line. The float valve maintains a constant water level in the supply tank and prevents the entrance of air into the pump suction. The total discharge from the tank, which should be ½ g.p.m or more, may be controlled by adjusting the hard-rubber cock. The tank should be equipped with an overflow which would function in case of failure to close the feeder discharge when the pump is not operating.

By using a similar arrangement and an injector, a chlorine solution can be applied against pressure. The pressure differential between the injector feed and the discharge should be about 5 to 1 and must be at least 3 to 1 to give satisfactory operation.

Another simple and accurate feeder for small installations is shown in Fig. 3.

Manufacturers producing one of the high-strength chlorine compounds are prepared to send to water works operators copies of booklets showing home-made chlorination apparatus. These booklets have instructions and tables showing how to construct and use the apparatus and how to prepare the solutions and test for chlorine residuals. Every operator should have one of these booklets on hand at all times.

7H.1-1941

Standard Specifications

for

Elevated Steel Water Tanks, Standpipes and Reservoirs

American Water Works Association

American Welding Society

—Reprinted 1941—

The American Water Works Association has adopted and promulgates these "Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs." They are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Fourth Printing, December 1941

AMERICAN WATER WORKS ASSOCIATION

22 East 40th St., New York, N. Y.

These Specifications are being published in the Journal by direction of the Executive Committee for the information of the members.

Foreword

These specifications were prepared by a joint committee of the American Water Works Association and the American Welding Society consisting of L. R. Howson, General Chairman, H. O. Hill, H. A. Sweet, C. W. Obert, J. P. Schwada, J. O. Jackson, H. C. Boardman and N. T. Veatch, Jr.

These specifications are a revision and extension to include welded construction of the specifications entitled "Standard Specifications for Riveted Steel Elevated Tanks and Standpipes" which were prepared by Subcommittee 7H of the American Water Works Association and published tentatively in the JOURNAL in December, 1931, and finally in the JOURNAL, November, 1935. Those specifications covered riveted construction only. The purpose of the present specifications is to provide a uniform guide for minimum requirements as to the design, fabrication and erection of elevated steel water tank, standpipe and reservoir structures of either welded or riveted construction.

All requirements relative to welding in these specifications have been taken from American Welding Society "Rules for Field Welding of Steel Storage Tanks."

These specifications were approved as "Tentative Standard" by the Executive Committee of the American Welding Society, April 4, 1940; and by the Board of Directors of the American Water Works Association, April 25, 1940. These specifications were approved as "Standard" by the Board of Directors of the American Water Works Association on June 26, 1941; and by the Executive Committee of the American Welding Society on July 23, 1941.

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Standard Specifications
for
Elevated Steel Water Tanks, Standpipes and Reservoirs

Section 1—General

1.01 *Local Requirements.* Where local, municipal, county, state or government requirements exist such requirements are to govern and these specifications shall be interpreted to supplement them.

1.02 *Definitions.* Under these specifications the following definitions will apply:

Elevated Tank shall mean a container or storage tank supported on a tower.

Standpipe shall mean a flat bottom cylindrical tank having a shell height greater than its diameter.

Reservoir shall mean a flat bottom cylindrical tank having a shell height equal to or smaller than the tank diameter.

Tank shall mean an elevated tank, a standpipe or a reservoir.

Purchaser shall mean the person, company or organization which purchases the tank.

Engineer shall refer to the purchaser's engineer.

Contractor shall mean the person or company who contracts with the purchaser under these specifications to furnish and erect the tank.

Capacity shall mean that contained between the level of the overflow and the lowest specified level.

1.03 *What the Purchaser Is to Furnish.* The purchaser shall furnish the site upon which the tank is to be built with sufficient space to permit the contractor to erect the structure using customary methods. The purchaser shall furnish foundations. Unless otherwise agreed the purchaser shall furnish at the tank site the water at the proper pressure for testing and facilities for disposing of waste water, after testing. The purchaser shall furnish a suitable right of way from the nearest public road to the erection site.

1.04 *What the Contractor Is to Furnish.* The contractor shall furnish foundation plans, the anchor bolts, all materials except for foundations, all labor necessary to complete the structure including

the accessories required by these specifications and any additional work or accessories separately specified by the purchaser.

1.05 *Information to Be Furnished by Purchaser.* In his advertisement or inquiry the purchaser shall furnish the information itemized in Section A-2 for elevated tanks or that in Section A-3 for standpipes or reservoirs.

1.06 *Information to Be Furnished by Bidder.* Each bidder shall furnish the information itemized in Section A-4 for elevated tanks or that in Section A-5 for standpipes or reservoirs.

1.07 *Guarantee.* The contractor shall guarantee the structure against any defective materials or workmanship including paint and painting if in accordance with Sections A-8, A-9 and A-10 for a period of one year from date of completion. If any materials or workmanship prove to be defective within one year they shall be replaced or repaired by the contractor.

Section 2—Materials

2.01 *Bolts, Anchor Bolts and Threaded Rods.* Bolts, anchor bolts and threaded rods shall conform with any of the following A.S.T.M. Specifications: A 7, Bolting Material; A 10; A 78 (for welded construction specify for fusion welding); or A 141, latest revision.

For welded construction the carbon content should not exceed 0.30 per cent nor the manganese 1.00 per cent (by ladle analysis).

2.02 *Reinforcing Steel.* Reinforcing steel shall comply with the latest revision of A.S.T.M. Specifications A 15 (structural or intermediate grade).

2.03 *Plates.* Plate materials shall be open hearth steel conforming to the latest revision of any of the following A.S.T.M. Specifications A 7, A 10, A 70, A 78, A 89 (for welded construction specify for fusion welding) or A 113 (cold pressing grade).

For welded construction the carbon content shall not exceed 0.30 per cent, nor the manganese content 1.00 per cent (by ladle analysis).

2.04 *Basis of Furnishing Plates.* Plates shall be furnished to average weight per square foot with permissible underrun and overrun according to the tolerance table for plates ordered to weight published in the applicable A.S.T.M. specification. Plate thicknesses shown on purchaser's or contractor's plans or specifications shall be converted to average weight per square foot by multiplying the thickness in inches by 40.8.

2.05 *Structural Shapes.* Structural materials shall be open hearth steel conforming to the latest revision of A.S.T.M. Specifications A 7 or A 10.

For welded construction the carbon content shall not exceed 0.30 per cent, nor the manganese content 1.00 per cent (by ladle analysis).

2.06 *Copper Bearing Steel.* Copper bearing steel with content of about 0.20 per cent copper may be used when specified. In other particulars the steel shall conform to specifications enumerated above.

2.07 *Rivets.* Rivets shall comply with the latest revision of A.S.T.M. Specifications A 31 or A 141. If cold driving is done, properly annealed rivets conforming to A.S.T.M. Specifications A 31 should be used.

2.08 *Pins.* Pins shall comply with A.S.T.M. Specifications A 108 Grade 5, latest revision.

2.09 *Castings.* Castings for riveted construction shall conform to the latest revision of A.S.T.M. Specifications A 27, Grade A-3.

Castings for welded construction shall conform to the latest revision of A.S.T.M. Specifications A 215, Grade A-3-W (carbon content not to exceed 0.25 per cent by ladle analysis).

2.10 *Forgings.* Forgings shall conform to the latest revision of one of the following A.S.T.M. Specifications: (For welded construction in no case shall the carbon content exceed 0.30 per cent by ladle analysis.)

(*a*) Plate Forgings—A 78 and A 89 (for welded construction specify for fusion welding).

(*b*) Forgings, other than plate,—A-235, Class B.

(*c*) Forged and Rolled Pipe Flanges,—A 181, Class I.

2.11 *Filler Metal.* The specifications cited below shall be followed for filler metal:

(*a*) Electrodes shall conform to the A.W.S.—A.S.T.M. "Specifications for Iron and Steel Arc Welding Electrodes," serial designation A 233, of the latest revision, using the following classifications: E 6010, E 6011, E 6012, E 6013, E 6020 and E 6030.

The classification number selected must be suitable for the electric current characteristics and also for the position of welding.

(*b*) Gas welding rods shall conform to the A.W.S.—A.S.T.M. "Specifications for Iron and Steel Gas Welding Rods," of the latest revision, using the G-60 classification.

Section 3—General Design

3.01 *Type of Joints.* Unless specifically restricted by the purchaser, joints and connections in structures built under these specifi-

cations may be either riveted or welded or parts may be riveted or welded at the option of the contractor.

Lap welded joints between plates in contact with tank contents except bottom plates supported directly on grade or foundation shall be welded continuously on both edges.

3.02 *Design Loads.* The following loads shall be considered in the design of tank structures:

(*a*) *Dead load* shall be the estimated weight of all permanent construction and fittings. The unit weight of steel shall be considered 490 lb. per cu.ft. and of concrete 144 lb. per cu.ft.

(*b*) *Live load* shall be the weight of all of the liquid when the tank is filled to overflowing. Unit weight of water shall be considered as 62.4 lb. per cu.ft. The weight of any water, supported directly on foundations, shall not be considered as a live load on the superstructure.

(*c*) *Snow load* shall be 25 lb. per sq.ft. of the horizontal projection of the tank for surfaces having a slope of less than 30° with the horizontal. For greater roof slope snow loads shall be neglected.

(*d*) *Wind load* or pressure shall be assumed to be 30 lb. on vertical plane surfaces, 18 lb. on projected areas of cylindrical surfaces and 15 lb. per sq.ft. on projected areas of conical and double curved plate surfaces. (It may be desirable to increase the wind loads above by as much as 50 per cent in hurricane areas.)

For columns and struts of structural shapes the equivalent flat vertical surface area shall be calculated.

In calculating the wind load on elevated tank structures the entire wind load on the tank, roof and bottom and the proper proportion of the wind load from the riser pipe and tower shall be assumed to act on the tank at the center of gravity of such loads.

(*e*) *Earthquake Load:* If any provision is to be made in the design for earthquake resistance the purchaser shall so specify. *Note:* Present practice is to assume a horizontal force of from 5 to 20 per cent of the total weight of the water in the tank and riser acting at the center of mass of the water, the percentage used depending upon the proximity of an earthquake-producing fault and the hazard to surrounding property in the event of an earthquake failure or upon local regulations.

(*f*) *Balcony and Ladder Load:* A vertical load of 1,000 lb. shall be assumed to be applied to any point on the balcony floor, if any, and on each platform; 500 lb. at any point on the tank roof; 350 lb. on each section of ladder; and all of the structural parts and connections shall be properly proportioned to withstand such loads.

3.03 *Unit Stresses.* With the exceptions specifically provided for elsewhere in these specifications, all steel members shall be so designed and proportioned that, during the application of any of the loads previously specified, or any combination of them, the maximum stress shall not exceed the following:

	Maximum Fiber Stress Pounds Per Square Inch
(*a*) *Tension:*	
Structural steel	15,000
Rivets, on area based on nominal diameter	11,250
Bolts, on area based on diameter at root of threads	11,250
Cast steel	11,250
(*b*) *Compression:*	
Structural steel and weld metal	15,000
Columns and struts	See Section 3.05
Plate girder stiffeners	15,000
Webs of rolled sections at toe of fillet	18,000
Cast steel	15,000
(*c*) *Bending:*	
Tension on extreme fibers, except column base plates	15,000
Column base plates	20,000
Compression on extreme fibers of rolled sections, and built-up girders and built-up members, for values of $\frac{l}{b}$ not greater than 40, where l is laterally unsupported length of the member and b is the width of the compression flange	$\frac{16{,}875}{1 + \frac{l^2}{1{,}800b^2}}$ with a maximum of 15,000
Pins, extreme fiber	22,500
Cast steel	11,250
(*d*) *Shearing:*	
Rivets	11,250
Pins and turned bolts in reamed or drilled holes	11,250
Unfinished bolts	7,500
Webs of beams and plate girders, gross section	9,750
Cast steel	7,325

(e) *Bearing:*	*Double Shear*	*Single Shear*
Rivets	30,000	24,000
Turned bolts in reamed or drilled holes	30,000	24,000
Unfinished bolts	18,750	15,000
Pins	24,000	
Contact area of milled surfaces	22,500	
Contact area of fitted stiffeners	20,250	
Expansion rollers and rockers (pounds per lineal inch) where d is the diameter of roller or rocker in inches		$600d$
Concrete (see Section A-22)		
2,000 lb. Concrete		500
2,500 lb. Concrete		625
3,000 lb. Concrete		750

Unit stress values wherever stated in these specifications shall be reduced by multiplying them by the applicable joint efficiencies.

3.04 *Combined Stresses.*

(*a*) *Axial and Bending:* Members subjected to both axial and bending stresses shall be so proportioned that the quantity $\frac{fa}{Fa} + \frac{fb}{Fb}$ shall not exceed unity, in which:

Fa is the axial unit stress that would be permitted by this specification if axial stress only existed.

Fb is the bending unit stress that would be permitted by this specification if bending stress only existed.

fa is the axial unit stress (actual) = axial stress divided by area of member.

fb is the bending unit stress (actual) = bending moment divided by section modulus of member.

(*b*) *Rivets:* Rivets subject to shearing and tensile forces shall be so proportioned that the combined unit stress will not exceed the allowable unit stress for rivets in tension only.

(*c*) *Wind and Other Forces:* Members including foundations subject to stresses produced by a combination of wind and/or earthquake and other loads may be proportioned for unit stresses 25 per cent greater than those specified in Sections 3.03 and 3.05, provided the section thus required is not less than that required for the combination of dead load and live load.

Members subject only to stresses produced by wind forces and/or earthquake forces may be proportioned for unit stresses 25 per cent greater than those specified in Sections 3.03 and 3.05.

3.05 *Column and Strut Formulas.* The following formulas shall be applied:

(*a*) *Structural Sections:* The maximum permissible unit stress for structural columns or struts shall be determined from the following formula:

$$\frac{P}{A} = \left[\frac{18000}{1 + \frac{L^2}{18000r^2}}\right]$$

$\frac{P}{A}$ in no case to exceed 15,000 lb. per sq.in.

(*b*) *Tubular Sections:* The maximum permissible stress for tubular columns and struts shall be determined by the following formula.

$$\frac{P}{A} = \left[\frac{18000}{1 + \frac{L^2}{18000r^2}}\right]\left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\left[2 - \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\right]$$

$\frac{P}{A}$ in no case to exceed 15,000 lb. per sq.in.

In the above formula the term $\left[\frac{18000}{1 + \frac{L^2}{18000r^2}}\right]$ shall not exceed 15,000 lb. per sq.in.

In the above formula the term $\left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\left[2 - \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\right]$ shall be evaluated as unity (one) for values of $\frac{t}{R}$ equal to or exceeding 0.015.

In the foregoing formulas the symbols have the following meaning:

P = the total axial load in pounds.
A = the cross sectional area in square inches.
L = the effective length in inches.
r = the least radius of gyration in inches.
R = the radius of the tubular member to the exterior surface in inches.
t = the thickness of the tubular member in inches; minimum allowable thickness $\frac{1}{4}$ in.

All circumferential joints in tubular sections shall be butt joints either welded for complete penetration or riveted with butt straps on both sides.

3.06 *Slenderness Ratio.* The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying weight or pressure of tank contents shall be 120.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying loads from wind and/or earthquake only shall be 175.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for columns carrying roof loads only shall be 175.

3.07 *Roofs and Top Girders.* All tanks storing drinking water should have roofs. Tanks without roofs shall have a top girder or angle having a minimum section modulus as determined by the following formula:

$$S = \frac{HD^2}{10000}$$

In the above formula S is the minimum required section modulus in inches cubed of the top angle or girder, including a length of tank shell equal to twenty times its thickness; H is the height of the cylindrical portion of the tank shell in feet; and D is the diameter of the cylindrical portion of the tank shell in feet.

3.08 *Roof Supports.* Roof supports, if any, shall be designed in accordance with the current specifications of the American Institute of Steel Construction, except that the ratio $\frac{l}{b}$ of unbraced length to width of flange of rafters in contact with roof sheets shall not be restricted, as it is considered that the roof sheets will provide lateral supports for the rafters, and except that the maximum slenderness ratio $\frac{L}{r}$ for columns supporting roofs shall be 175.

Roof trusses shall be placed above the maximum water level in climates where ice may form.

Roof rafters shall preferably be placed above the maximum water level but it will be permissible for their lower ends, where they connect to the tank shell, to project below the water level.

3.09 *Foundation Bolts.* Foundation bolts may be either plain or deformed bars, either upset or not upset. They shall be proportioned for the maximum possible uplift, using the area at the base of the thread or the un-upset rod diameter whichever is smaller. Foundation bolts may extend into the pier to within 3 in. from the bottom of the pier, but not necessarily more than far enough to develop the maximum uplift, and shall terminate in a right angle bend, hook or washer plate. The threaded ends of foundation bolts shall extend 2 in. above the nominal level of the tops of the foundation bolt nuts to provide for variations in the foundations. Lock nuts shall be

provided or the threaded ends of anchor bolts shall be peened to prevent loosening of anchor nuts.

3.10 *Corrosion Allowance.* Careful consideration shall be given by the purchaser to the proper allowance for corrosion. This allowance will depend upon the corrosive nature of the stored water, the proximity of the tank to salt water or other causes of atmospheric corrosion and the care with which the paint or other protection will be maintained. If corrosion allowance is desired the purchaser shall specify the allowance for parts in contact with water and for parts not in contact with water. The corrosion allowance specified by the purchaser is to be added to the thickness determined from the specified design units and to the minimum thicknesses specified in the following section. In the case of beams and channels, the corrosion allowance need be added to the webs only and not to the flanges.

3.11 *Minimum Thickness.* The minimum thickness for any part of the structure shall be $\frac{3}{16}$ in. for parts not in contact and $\frac{1}{4}$ in. for parts in contact with water contents. The minimum thickness for tubular columns and struts shall be $\frac{1}{4}$ in. Round or square bars used for wind bracing shall have a minimum diameter or width of $\frac{5}{8}$ in. Bars of other shapes, if used, shall have a total area at least equal to a $\frac{5}{8}$ in. round bar.

3.12 *Joints in Shell Plates.* In calculating the thicknesses of plates stressed by the weight or pressure of the tank contents, the pressure at the lower edge of each ring shall be assumed to act undiminished on the entire area of the ring. Joints subjected to stress from weight or pressure of tank contents in adjacent courses shall be staggered.

3.13 *Riveted Joint Design.* The riveted joint design shall comply with current good practice as regards the size of rivets, edge distance for calking and non-calking edges, the angle of bevel of calking edges and the minimum and maximum rivet pitches and back pitches.

The following represents good practice:

The minimum rivet pitch shall be not less than three times the nominal diameter of the rivet.

The maximum pitch along a calked edge where the calking is necessary for water tightness shall be ten times the thickness of the thinnest plate connected.

Maximum pitch along uncalked edges of tank plates shall not exceed 30 times the thickness of the thinnest plate connected.

The distance between the center of the outer row of rivets and the edge of plate shall not be less than 1.5 times the diameter of the rivets. Where edges are beveled, the distance from the center of rivets to the toe of the bevel shall not exceed 1.75 times the diameter of the rivets.

Spacing between rows of rivets shall be as follows:

(*a*) For joints where one rivet in the inner row comes midway between two rivets in the outer row, the spacing between the rivets or back-pitch shall be $1.75d + 0.185\ (P - 4d)$, with a minimum of $1.75d$.

(*b*) For joints where two rivets in the inner row are placed between two rivets in the outer row, the back-pitch shall equal $2d + 0.14\ (P - 4d)$, with a minimum of $2d$.

P is the pitch, in inches, of the rivets in the outer row.

d is the diameter of the rivet holes in inches.

3.14 *Riveted Joint Efficiency.* The joint efficiency for riveted joints shall be calculated on the basis of the previously specified unit stresses.

For punched holes the shear and bearing of rivets shall be based on the nominal rivet diameter and the net tension or tearing shall be based on the nominal rivet diameter plus $\frac{1}{8}$ in.

For drilled or subpunched and reamed holes the shear, bearing and tension or tearing shall be based on the drilled or reamed diameter of the holes.

The joint shall be designed and the efficiency determined before adding the corrosion allowance.

3.15 *Weld Design Values—Structural Joints.* Welded joints shall be proportioned so that the stresses on a section through the throat of the weld, exclusive of weld reinforcement, shall not exceed the following percentages of the allowable working tensile stress of the structural material joined.

(*a*) *Groove Welds:*	
Tension	85 per cent
Compression	100 per cent
Shear	75 per cent
(*b*) *Fillet Welds:**	
Transverse Shear	65 per cent
Longitudinal Shear	50 per cent

* Stress in a fillet weld shall be considered as shear on the throat, for any direction of the applied load. The throat of a fillet weld shall be assumed as 0.707 times the length of the shorter leg of the fillet weld.

3.16 *Weld Design Values—Tank Plate Joints.*

Type of Joint	*Efficiency Per Cent*
(a) Double-welded butt joint with complete penetration.	85 Tension; 100 Compression
(b) Double-welded butt joint with partial penetration and	$85\frac{Z}{T}$ Tension; $100\frac{Z}{T}$ Compression

with the unwelded portion located substantially at the middle of the thinner plate.

Where Z is the total depth of penetration from the surfaces of the plate, (use the thinner plate if of different thicknesses);
T is the thickness of the plate, (use the thinner plate if of different thicknesses).

(c) Single-welded butt joint with suitable backing-up strip or equivalent means to insure complete penetration.	85 Tension; 100 Compression
(d) Double-welded lap joint with full-fillet weld on each edge of joint.	75 Tension or Compression
(e) Double-welded lap joint with full-fillet weld on one edge of joint and an intermittent full-fillet weld on the other edge of joint.	$75\frac{(1+X)}{(2)}$ Tension or Compression

Where X is the percentage of full-fillet intermittent welding, expressed as a decimal.

(f) Lap joint with full-fillet welds, or smaller, on either or both edges of the joint, welds either continuous or intermittent.	$75\frac{(XW_1 + YW_2)}{2T}$ Tension or Compression

Where X and Y are the percentages of intermittent welds for welds W_1 and W_2 respectively, expressed as a decimal.

W_1 and W_2 are the sizes of the welds on each edge of the joint respectively.
(W_2 will be zero for a joint welded on one edge only.)
T is the thickness of plate, (use the thinner plate if of different thicknesses).

3.17 *Reinforcement Around Openings.* All openings over 4 in. in diameter in the shell or suspended bottom of the tank shall be reinforced. This reinforcement may be the flange of a fitting used or an additional ring of metal, or both flange and ring.

The amount of reinforcement for a riveted tank shell shall be computed as follows:

(*a*) In computing the necessary reinforcement of an opening in a tank shell, the net area of the reinforcement shall bear the same ratio to the area of the metal removed from the shell as the strength of the vertical joint in the shell course bears to the strength of the solid plate.

(*b*) Sufficient rivets shall be used to transmit to the shell plate by shear the full strength of the reinforcing ring or flange, at a maximum unit shear of 75 per cent of unit tensile stress used in designing the shell plate.

The amount of reinforcement for a welded tank shell shall be computed as follows:

(*c*) The strength of the required reinforcement around an opening in a shell plate shall be based on the vertical cross-sectional area of the metal removed from the plate. This area shall be taken as the product of the vertical diameter of the hole cut in the shell plate and the thickness of the plate (100 per cent reinforcement). The strength through the net cross-sectional area of the reinforcement added, lying in a vertical plane (plane of reinforcement) coincident with the axis of the opening, shall at least equal that of the product referred to above.

(*d*) The aggregate strength of the welding attaching a fitting to the shell plate and/or any intervening reinforcing plate shall at least equal the proportion of the forces passing through the entire reinforcement that is computed to pass through the fitting considered.

(*e*) The aggregate strength of the welding attaching any intervening reinforcing plate to the shell plate shall at least equal the proportion of the forces passing through the entire reinforcement, that is computed to pass through the reinforcing plate considered.

(*f*) The strength of the attachment welding shall be based only on that part of the outer peripheral welding which lies on either side outside the area bounded by vertical lines drawn tangent to the shell opening plus all of the inner peripheral welding that is applied on either side of the plane of reinforcement. This shall be taken as the total shear resistance of the above mentioned attachment welding. The outer peripheral weld shall be made as large as possible and the inner peripheral weld large enough to carry the remainder of the total loading.

(*g*) In computing the net reinforcing area of a fitting, such as a boiler maker's flange, or a manhole saddle, having a neck, the material in the neck may be considered as part of the reinforcing for a height, measured from the surface of the shell plate or that of an intervening reinforcement plate, equal to four times the thickness of the material in the neck.

Section 4—Design of Standpipes and Reservoirs

4.01 *Standard Capacities.* The standard capacities for standpipes and reservoirs shall be those recommended by the Division of Simplified Practice of the Department of Commerce and shall be as follows.

United States Gallons	United States Gallons
50,000	500,000
60,000	750,000
75,000	1,000,000
100,000	1,500,000
150,000	2,000,000
200,000	2,500,000
250,000	3,000,000
300,000	4,000,000
400,000	

4.02 *Standard Shell Height for Standpipes.* The purchaser shall preferably specify one of the following standard shell heights for standpipes:

Shell Heights from 20 ft. to 50 ft. by even 2-foot intervals
Shell Heights from 50 ft. to 100 ft. by even 5-foot intervals
Shell Heights from 100 ft. to 200 ft. by even 10-foot intervals

The purchaser shall preferably specify the required shell height and the capacity, the exact diameter being determined by the contractor. As here used shell height means height to overflow.

4.03 *Standard Diameters for Reservoirs.* The purchaser shall preferably specify one of the following standard diameters for reservoirs in order to promote standardization of drawings:

Diameters from 20 ft. to 50 ft. by even 2-foot intervals.
Diameters from 50 ft. to 100 ft. by even 5-foot intervals.
Diameters from 100 ft. to 200 ft. by even 10-foot intervals.

For reservoirs the purchaser shall specify the diameter and capacity, the exact height being determined by the contractor.

Section 5—Design of Elevated Tanks

5.01 *Standard Capacities.* The standard capacities for elevated tanks shall preferably be those recommended by the Division of Simplified Practice of the Department of Commerce as follows.

United States Gallons	United States Gallons	United States Gallons
5,000	60,000	500,000
10,000	75,000	750,000
15,000	100,000	1,000,000
20,000	150,000	1,500,000
25,000	200,000	2,000,000
30,000	250,000	2,500,000
40,000	300,000	
50,000	400,000	

5.02 *Standard Heights for Elevated Tanks.* The height of elevated tank structures shall be measured from the underside of the bases of the steel columns to the lower capacity level. The purchaser shall preferably specify one of the following standard heights:

Heights from 20 ft. to 50 ft. by even 2-foot intervals.
Heights from 50 ft. to 100 ft. by even 5-foot intervals.
Heights from 100 ft. to 200 ft. by even 10-foot intervals.

5.03 *Standard Ranges of Head.* By range of head is meant the vertical distance between the lower capacity level and the overflow between which the required capacity is contained. Where range of head is not material the purchaser shall preferably leave the determination of the range of head to the contractor.

If a special "low" range of head is required the purchaser shall preferably specify ranges of head by even 5-foot intervals.

5.04 *Columns and Struts.* The column base, whether riveted or welded, shall have sufficient area to distribute the column load over the concrete foundations without exceeding the specified bearing stress on the foundation and the connection of the column to the base plate shall provide for the maximum uplift, if the anchors are connected to the base plates and not to the column shaft.

5.05 *Column Splices.* Column splices shall be designed to withstand the maximum possible uplift, or at least 25 per cent of the maximum compression whichever is greater.

If column splices are riveted, the flanges only of rolled column

sections need be spliced. Rolled channels, if used in columns, shall have both the flanges and webs spliced. For welded column splices the joints may either be butt welded or splice plates may be welded to both sections being joined.

5.06 *Bottom Struts.* Bottom struts of steel or reinforced concrete shall be provided where necessary to distribute the horizontal reactions at the bases of the columns.

5.07 *Tension Members Carrying Wind and/or Earthquake Loads.* Such members shall be designed to resist the wind load and the earthquake load, if the latter is specified. If the projected centers of gravity of tension members do not meet the projected center of gravity of strut members at the center of gravity of the columns, proper allowance shall be made for the eccentricity.

Diagonal tension members shall be pre-stressed sufficiently to be taut when the tank is full. Such pre-stressing shall not be given consideration in the design of the members.

5.08 *Horizontal Girders.* For elevated tanks with inclined or battered columns connecting to the tank shell a horizontal girder shall be provided to resist the horizontal component of the column loads.

This girder shall be proportioned to withstand safely as a ring girder the horizontal inward component of the load on the top columns.

If the centers of gravity of the horizontal girder, the top section columns and the tank shell do not meet in a point, provision shall be made in the design of each of them for stresses resulting from any eccentricity.

5.09 *Balcony Railing.* If the horizontal girder is used as a balcony it shall be at least 24 in. in width and shall be provided with a railing at least 36 in. in height.

5.10 *Tank Plates.* Plates for elevated tank bottoms, shells and roofs may be any desired shape. Tank plates shall be designed on the basis of the following maximum fiber stresses which shall be reduced for the joint efficiencies as specified elsewhere in these specifications.

Plate surfaces susceptible to complete stress analysis shall be designed on the basis of a maximum fiber stress of 15,000 lb. per sq.in. Such plate surfaces include those not stressed by the concentrated reactions of supporting members or riser pipes.

Plate surfaces not susceptible to complete stress analysis shall also be designed on the basis of the maximum fiber stress of 15,000 lb. per sq.in. after making reasonable allowances for such loads and stresses

as cannot be accurately determined. The maximum fiber stress shall in no case exceed 11,000 lb. per sq.in. when calculated assuming that the concentrated reactions of supporting members are uniformly distributed between such reactions.

For example, consider an elevated tank having a vertical cylindrical shell supported by four columns attached to the shell and having a suspended ellipsoidal bottom with a central riser pipe and a cone roof uniformly supported by the tank shell. Under the meaning of these specifications, the stresses in the cylindrical shell and the ellipsoidal bottom cannot be determined, while those in the roof can be completely determined. The shell and bottom shall be designed on the basis of 15,000 lb. per sq.in. maximum fiber stress reduced for the joint efficiency used making allowances for the following:

(*a*) The hoop stresses caused by the weight or pressure of the tank contents, assuming that the cylindrical tank shell is uniformly supported on its entire lower circumference.

(*b*) The stresses in the cylindrical shell and ellipsoidal bottom, considering them acting together as a circular girder supported by the column reactions and subjected to torsion because of the portions projecting outward and inward from the chords connecting the columns.

(*c*) The horizontal inward component of the pull from the tank bottom (in the case of conical or segmental bottoms) causing compression in the tank shell.

(*d*) Stresses from any other causes.

After the cylindrical shell and bottom have been designed on the above basis, they shall be redesigned assuming that the cylindrical tank shell is uniformly supported on its entire lower circumference, and for this assumption the thicknesses of shell and bottom shall be increased, if necessary, so that the maximum calculated fiber stress shall not exceed 11,000 lb. per sq.in. reduced by the joint efficiency. In the case of riveted joints the redesign shall be based on the rivet values given in Section 3.03 reduced by the ratio of 11000 to 15000.

In designing bottoms of double curvature, consideration shall be given to the possibility of governing compressive stresses.

It is recognized that no specifications for the design of elevated tanks can be sufficiently specific and complete to eliminate the necessity of judgment on the part of the designer. It is also recognized that strain gage surveys are a proper source of design information.

5.11 *Steel Riser Pipe.* The steel riser pipe shall be designed to withstand stress caused by the weight or the pressure of the tank and riser contents and also the load imposed upon the top of the riser pipe by the tank bottom or by members supporting the tank bottom. If the design of the riser plates is controlled by hoop pressure, 0.3 of the compression in the vertical direction shall be added to the full calculated tension in the horizontal direction in determining the thickness. If controlled by column stresses the allowable column compressive stress shall not exceed the allowable stress calculated in accordance with Section 3.05, minus 0.3 of the calculated hoop stress.

The thickness of the bottom ring of the riser shall be sufficient so that the specified unit stresses shall not be exceeded when combined with bending or other stresses around manhole or other openings.

Section 6—Accessories for Standpipes and Reservoirs

6.01 *Shell Manhole.* A circular manhole 24 in. in diameter or an elliptical manhole 18 in. x 22 in. minimum size, with cover hinged to shell shall be furnished in the first ring of the tank shell at a location to be designated by the purchaser.

6.02 *Pipe Connection.* The pipe connection shall consist of a fitting of the size specified by the purchaser, attached to the tank bottom at a point designated by the purchaser, into which the connecting pipe may be calked. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the tank floor and provided with a removable silt stop 6 in. high.

6.03 *Overflow.* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified it shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified it shall be brought down the outside of the tank shell supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser allowing for full suction head. The top stiffener shall not be cut nor partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. in diameter or over.

6.04 *Outside Tank Ladder.* The contractor shall furnish a tank

ladder on the outside of the tank shell beginning 8 ft. above the level of the tank bottom and at a location to be designated by the purchaser, preferably near the manhole. The sides shall be not less than 2 in. x $\frac{5}{16}$ in. and the rungs not less than $\frac{5}{8}$ in. round or square bars. If a safety cage for this ladder is required by local laws or regulations the purchaser shall so specify.

6.05 *Roof Ladder.* In the case of standpipes with roofs, the contractor shall furnish a roof ladder attached to the roof finial with a swivel connection, the ladder to be equipped with rollers so that it will rotate around the standpipe roof. A roof ladder is not required on standpipe or reservoir roofs having a slope flat enough to walk on safely.

6.06 *Roof Hatch.* For standpipes or reservoirs with roofs, the contractor shall furnish a roof door or hatch, which shall be placed near the outside tank ladder and which shall be provided with hinges and a hasp for locking. The hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

6.07 *Vent.* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

6.08 *Additional Accessories.* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 7—Accessories for Elevated Tanks

7.01 *Tower Ladder.* A tower ladder with sides not less than 2 in. x $\frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square shall be furnished extending from a point 8 ft. above the ground up to and connecting with either the horizontal balcony girder or the roof ladder, if no balcony is used. The ladder may be vertical but shall not in any place have a backward slope.

7.02 *Outside Tank Ladder.* In all cases, a ladder shall be provided on the outside of the tank shell connecting either with the balcony or with the tower ladder if no balcony is included. The outside tank ladder shall have sides not less than 2 in. x $\frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square.

7.03 *Roof Hatch.* In all cases, there shall be provided a door or hatch immediately above the high water level, the hatch to be at least 24 in. square and to be provided with suitable hinges and a hasp to permit locking. Hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

7.04 *Roof Finial.* The roof shall be provided with a suitable finial.

7.05 *Roof Ladder.* Where practicable, there shall be furnished an outside roof ladder designed to rotate around the roof. If desired the roof ladder may be swiveled about the tank finial.

7.06 *Vent.* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

7.07 *Steel Riser Pipe.* In localities where freezing temperatures do not occur, the purchaser may specify a small steel riser pipe. In other locations and unless a small pipe is specified a steel riser pipe not less than 36 in. in inside diameter shall be furnished. In cases where the riser pipe supports a considerable load the riser diameter and thickness shall preferably be determined by the contractor.

In all cases where steel risers are used, there shall be furnished a manhole in the riser shell about three feet from the base of the riser, such manhole to be not less than 12 in. x 16 in. in size, the opening to be reinforced or the riser plate so designed that all stresses around the opening are provided for.

The above specified minimum riser diameter of 36 in. shall be increased in cold climates unless the riser is heated to prevent freezing. The proper diameter will depend upon the amount the tank is used and the temperature of the water supplied. In extreme cold climates a minimum diameter of 72 in. is recommended.

A safety grating shall be provided in the top of the riser pipe with no opening larger than 6 in. in width, except that a door at least 12 in. x 18 in. shall be provided.

7.08 *Pipe Connection.* The pipe connection into which the connecting pipe may be calked, shall consist of a fitting of the size specified by the purchaser, and shall be attached to the riser bottom at a point designated by the purchaser. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the riser floor and provided with a removable silt stop 6 in. high.

7.09 *Overflow.* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified, it

shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified, it shall be brought down the outside of the tank shell, supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser, allowing for full suction head. The top angle shall not be cut or partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. or over in diameter.

7.10 *Additional Accessories.* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 8—Welding

8.01 *Definitions and Symbols.*

(*a*) Welding terms employed in these rules shall be interpreted according to the definitions given in the latest edition of "Definitions of Welding Terms and Master Chart of Welding Processes," issued by the American Welding Society.

(*b*) Symbols used on construction drawings shall conform to those shown in the latest edition of "Welding Symbols and Instructions for Their Use," issued by the American Welding Society.

8.02 *Qualification of Welding Procedure and Testing of Welding Operators.* Welding procedure shall be qualified and welding operators shall be tested according to the latest rules of the American Welding Society for Standard Qualification Procedure, using the following values and modifying conditions:

(*a*) *Groove Welds for Primary Stress:*

(Joints subject to primary stress due to weight or pressure of tank contents.)

(1) Tension Test—Reduced-Section Tension Test—not less than 95 per cent of the minimum of the specified A.S.T.M. tensile range of the base material.

(2) Free Bend Test—minimum elongation 20 per cent.

(3) Root, Face and Side Bend Test—Any specimen in which a crack is present after the bending exceeding $\frac{1}{8}$ in. measured in any direction shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

(*b*) *Groove Welds for Secondary Stress:*

(Joints subject to secondary stress, those not directly affected by weight or pressure of tank contents.)

(1) Tension Test—Butt joints which do not require full penetration shall have the procedure qualified by the Reduced-Section Tension Test only. This test shall not be used for the qualification of welding operators. (See Section 8.04.)

(2) The Reduced-Section Tensile Test shall give values not less than 110 per cent of the specified strength of the joint.

(c) *Fillet Welds:*

(1) Transverse Shear Test—shall have a minimum value in pounds per square inch equal to $\frac{7}{8}$ of the minimum of the specified A.S.T.M. tensile range of the base material.

(2) Longitudinal Shear Test—shall have a minimum value in pounds per square inch equal to $\frac{3}{4}$ of the minimum of the specified A.S.T.M. tensile range of the base material.

(3) Fillet Weld Soundness Test—Any specimen in which a crack is present after the bending exceeding $\frac{1}{8}$ in. measured in any direction shall be rejected. Cracks occurring on the corners of the specimens during testing shall not be considered.

(4) Double-fillet-welded lap joints using various size welds, such as used to resist secondary stress, may be qualified with shear tests only, using the unit shear stress values given in paragraphs (1) and (2). Such tests shall not be used for the qualification of welding operators.

(d) *General:*

(1) An operator who has been qualified for welding on plate will be permitted to perform the incidental pipe welding required in the fabrication and attachment of tank appurtenances.

(2) The contractor shall submit qualification test reports for the procedure he intends to use—including all types of welded joints, welded in all positions to be used in the construction. These test reports shall bear proper witness certification of a reputable testing laboratory or inspection agency, stating that such tests were performed in accordance with the above mentioned requirements. The tests need not be repeated provided the procedure is not modified.

(3) All welding operators assigned to weld on tanks constructed under these rules shall have been tested under the

above mentioned American Welding Society "Standard Qualification Procedure." The contractor shall certify that such tests were performed in accordance with the above mentioned requirements.

(4) The operator qualification tests herein specified shall be considered as remaining in effect indefinitely unless (1) the welding operator has not been continuously employed by the contractor on similar work, using similar welding procedure, for a period of three months or more since making qualification tests; or unless (2) there is some specific reason to question an operator's ability. In case (1) above, the requalification test need be made only in the $\frac{3}{8}$ in. thickness.

(5) The contractor shall maintain a record of each welding operator employed by him, showing the dates and results of qualification tests and the work-identification mark assigned to him.

8.03 *Butt Joints Subject to Primary Stress from Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks).

These joints may be double welded to insure complete penetration; or they may be single welded with suitable backing-up strip or equivalent means to insure complete penetration.

8.04 *Butt Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells). These joints shall be designed to develop an efficiency of at least 57 per cent, based on the thickness of the thinner plate joined. They shall be double welded and may have partial penetration (at least $\frac{3}{4}$ penetration required) with the unwelded portion located substantially at the middle of the thinner plate. (This joint shall be at least equivalent to $\frac{3}{4}$ that of a double welded butt joint with full penetration.)

8.05 *Lap Joints Subject to Primary Stress from Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks).

These joints shall have continuous full-fillet welds on both sides of the joint. (Maximum thickness permitted for this type of joint is $\frac{1}{2}$ in.)

8.06 *Lap Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells).

These joints shall be welded on both sides with continuous fillet welds. They shall be designed to develop an efficiency of at least

50 per cent, based upon the thickness of the thinner plate joined. (This joint shall be at least equivalent to $\frac{3}{4}$ that of a double full-fillet lap joint.) (Maximum thickness permitted for this type of joint — $\frac{5}{8}$ in.)

8.07 *Flat Tank Bottoms Resting Directly on Grade or Foundation.* Bottoms shall be built to one of two alternative methods of construction:

(*a*) Lap joint construction—Bottom plates need be welded on the top side only with continuous full-fillet welds on all seams.

Marginal sketch plates under the bottom ring of cylindrical shells, in the case of lap joint construction, shall have the outer end of the joint fitted and welded with groove or fillet welds to form a smooth bearing under the shell. (Maximum thickness for lap welded bottoms shall be $\frac{1}{2}$ in.)

(*b*) Butt joint construction—These joints shall be single welded from the top side, using suitable backing-up strip or equivalent means to insure complete penetration.

8.08 *Shell to Bottom Joint* (applies to vertical cylindrical shells with flat bottoms). The attachment between the bottom edge of the lowest course shell plate and the bottom sketch plates shall be by a continuous fillet weld laid on both sides of the shell plate. The size of each weld shall be equal to the thickness of the sketch plate or the thickness of the shell plate, whichever is smaller, with a maximum size of $\frac{1}{2}$ in. The sketch plates shall extend outside the tank shell a distance of at least 1 in. beyond the toe of the weld.

8.09 *Roof Plates.*

(*a*) Roofs not subject to hydrostatic pressure from tank contents—such roof plates need be welded on the top side only with continuous full-fillet welds on all seams.

(*b*) Roofs subject to hydrostatic pressure from tank contents—such roof plate joints shall be designed to conform to the efficiency values given in Section 3.16.

8.10 *Maximum Thickness of Material to Be Welded.*

(*a*) Maximum thickness permitted for lap joints subject to primary stress from weight or pressure of tank contents—$\frac{1}{2}$ in. (e.g., vertical joints of cylindrical tank shells; all joints below the points of support in elevated tanks).

(*b*) Maximum thickness permitted for lap joints, subject to secondary stress—$\frac{5}{8}$ in. (e.g., horizontal joints of cylindrical tank shells).

(*c*) Maximum thickness for lap joints in flat tank bottoms resting directly on grade or foundation—$\frac{1}{2}$ in.

(*d*) Maximum thickness of metal permitted to be field welded—$1\frac{1}{2}$ in.

8.11 *Minimum Laps for Lap Joints.*

(*a*) Joints subject to primary stress from weight or pressure of tank contents—5 *T* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms).

(*b*) Joints subject to secondary stress—3 *T* with a minimum of 1 in. (e.g., horizontal joints of cylindrical tank shells, flat tank bottoms and roofs not subject to hydrostatic pressure from tank contents).

Where, *T* is the thickness of material welded, (use the thinner plate if of different thicknesses).

8.12 *Intermittent Welding.*

(*a*) The length of any segment of intermittent weld shall be not less than four (4) times the weld size with a minimum of $1\frac{1}{2}$ in.

(*b*) Intermittent welding shall not be used on tank shell plating.

(*c*) Intermittent groove welds shall not be used.

(*d*) All seams of intermittent welding shall have continuous welds at each end for a distance of at least 6 in.

8.13 *Minimum Size Fillet and Seal Welds.*

(*a*) Plates $\frac{3}{16}$ in. and less in thickness shall have full fillet welds. Plates over $\frac{3}{16}$ in. thick shall have welds of size not less than $\frac{1}{3}$ the thickness of the thinner plate at the joint, with a minimum of $\frac{3}{16}$ in.

(*b*) Sealing, when desired, shall not be accomplished by running a bead of minimum dimension along the intervals between intermittent strength welds, but by applying a continuous weld, combining the functions of sealing and strength and changing section only gradually and as changes in the required strength may necessitate.

8.14 *Minimum Length of Welds.*

(*a*) The minimum length of any weld shall be four (4) times the size, with a minimum of $1\frac{1}{2}$ in., or else the size of the weld shall be considered not to exceed one-fourth its length.

(*b*) The effective length of a fillet weld shall not include the length of tapered ends. A deduction of at least $\frac{1}{4}$ in. shall be made from the overall length as an allowance for the tapered ends.

Section 9—Shop Fabrication

9.01 *Workmanship.* All workmanship done on tanks being built under these specifications shall be first class in every respect.

9.02 *Straightening.* Any required straightening of material shall be done by methods which will not injure the steel. Straightening

by hammering will not be permitted but shall be done cold by rolling or pressing.

9.03 *Laying Out.* Laying out shall be done by experienced workmen only. Rivet holes shall be accurately spaced so that they come opposite each other in adjoining parts. If, upon assembling, holes do not match within $\frac{1}{8}$ in. for punched holes or $\frac{1}{16}$ in. for drilled or reamed holes, the inspector may order the contractor to ream the holes to a larger size and to use larger rivets, or, if the error is too great to permit this, the plate or plates containing such unfair holes may be rejected at the option of the inspector.

9.04 *Rivet Holes.* Rivet holes in material $\frac{5}{8}$ in. thick and under may be punched or drilled full size.

Rivet holes in material over $\frac{5}{8}$ in. to and including $\frac{3}{4}$ in. thick shall be either drilled from the solid or punched $\frac{1}{16}$ in. smaller in diameter than the nominal diameter of the rivet and then reamed to size.

Rivet holes in material over $\frac{3}{4}$ in. thick shall be drilled.

The final diameter of rivet holes shall be not more than $\frac{1}{16}$ in. larger than the rivets.

9.05 *Plate Edges—Riveted Work.* Edges of plates which are to be calked shall be beveled either by shearing, machining, or cutting with a machine operated gas torch, except that plates over $\frac{5}{8}$ in. thick shall not be sheared.

Plates $\frac{1}{2}$ in. and less in thickness may be beveled to approximately a 60- to 70-degree angle. Plates over $\frac{1}{2}$ in. in thickness may be beveled to an angle of approximately 75 to 80 degrees.

9.06 *Finish of Plate Edges—Welded Work.*

(*a*) The welding edges of plates may be universal mill edges or they may be prepared by shearing, machining, chipping, or by mechanically guided gas-cutting, except that irregular edges may be prepared by manually guided gas-cutting.

(*b*) When edges of plates are gas cut, the resulting surface must be uniform and smooth and must be freed of slag accumulations before welding. All cutting shall follow closely the lines prescribed.

(*c*) Shearing of material for butt joints shall be limited to a thickness of $\frac{1}{2}$ in., or less. Material for all permitted thicknesses of lap joints may be sheared.

9.07 *Scarfing for Riveted Construction.* Scarfing may be done either by heating the corners to be scarfed to a cherry-red color, then forging while hot, or the scarf may by forging in the cold either by hydraulic or mechanical pressing.

9.08 *Rolling.* Plates shall be cold rolled to the proper curvature in accordance with the following table.

Plate Thickness	*Minimum Diameter for Plates Not Rolled*
Plates less than $\frac{3}{8}$ in.	30 ft.
$\frac{3}{8}$ in. to less than $\frac{1}{2}$ in.	60 ft.
$\frac{1}{2}$ in. to less than $\frac{5}{8}$ in.	120 ft.
$\frac{5}{8}$ in. and heavier	Must be rolled for all diameters

All butt straps are to be formed to the proper curvature.

9.09 *Double Curved Plates.* Plates which are curved in two directions may be pressed either cold or hot or may be dished with a "mortar and pestle" die by repeated applications.

9.10 *Milling Columns.* The ends of columns shall be milled to provide a satisfactory bearing unless the design contemplates sufficient riveting or welding to resist the total calculated loads.

9.11 *Shop Assembly.* Double-curved tank bottoms, shells, and roofs, shall be assembled in the shop, if necessary, to insure their fitting properly in the field.

9.12 *Shipping.* All materials shall be loaded on cars, unloaded, transported to the site and stored in such manner as to prevent damage.

Section 10—Erection

10.01 *General.* The contractor shall furnish all labor, liability and compensation insurance, tools, falsework, scaffolding and other equipment necessary and erect the tank complete ready for use. He shall furnish to the purchaser certificates of insurance coverage.

10.02 *Riveted Tanks.* Plates shall be carefully and accurately laid up and shall then be firmly drawn together with machine bolts or wedge bolts before riveting is started.

No paint or foreign materials shall be used between surfaces in contact.

Rivets under $\frac{5}{8}$ in. in diameter may be driven hot or cold. All rivets $\frac{5}{8}$ in. in diameter and larger shall be driven hot.

Hot driven rivets shall be driven by pneumatic or hydraulic tools whenever possible.

Rivets shall be driven with either cone, steeple or button shaped snaps, except that cold rivets may be driven with mushroom heads.

Heads shall be as nearly as possible concentric with the rivet body. All rivets shall be driven from the side of the plate which calks.

Any burned, loose or defective rivets shall be cut out and redriven.

Riveted seams shall be made tight by calking. The portion of the

roof, if any, containing water shall be calked, the remainder of the roof need not be calked. Calking tools and methods used shall be such that the underlying sheet is not damaged and the edge of the top sheet is not turned under. The work must be done by experienced men only.

The opening between ends of plates and outside butt straps shall be stopped by means of a wedge or by welding.

10.03 *Welded Tanks.* If painting is required on underside of flat tank bottom, the bottom plates shall be spread out and painted. After the paint has dried the plates shall be moved to their proper location on the foundations and turned over in place with as little subsequent moving as possible in order not to damage the paint film.

The bottom plates shall be assembled and welded together following a procedure which will result in a minimum of distortion from weld shrinkage.

All shell, bottom and roof plates subjected to stress by the weight or pressure of the contained liquid shall be assembled and welded in such a manner that the proper curvature of the plates in both directions is maintained.

Extra holes in the plates for erection purposes may be used provided the holes are later filled with rivets or weld metal in compliance with Section 11.09.

Any clips, jigs or lugs welded to the shell plates for erection purposes shall be removed without damaging the plates and any portion of weld beads remaining shall be chipped or ground smooth.

10.04. *Welds—General.* All welds in the tank and structural attachments shall be made in a manner to insure complete fusion with the base metal, within the limits specified for each joint, and in strict accordance with the qualified procedure.

10.05. *Preparation of Welding Surfaces.* Surfaces to be welded shall be free from loose scale, slag, heavy rust, grease, paint and any other foreign material excepting tightly adherent mill scale. A light film of linseed oil or spatter film compound may be disregarded. Joint surfaces shall be smooth, uniform, and free from fins, tears, and other defects which adversely affect proper welding. A fine film of rust, adhering after wire brushing on cut or sheared edges that are to be welded, need not be removed.

10.06 *Weather Conditions.* Welding shall not be done when the temperature of the base metal is less than 0°F.; when surfaces are wet from rain, snow or ice; when rain or snow is falling on the surfaces to be welded; or during periods of high wind, unless the operator and the work are properly protected. At temperatures between

32°F. and 0°F., the surface within 3 in. of the point where the weld is to be started, shall be heated to a temperature warm to the hand before the welding is started.

10.07 *Cleaning Between Passes.* Each pass of weld metal on multi-pass welding shall be cleaned of slag and other loose deposits before applying the next pass.

10.08 *Tack Welds.* Erection tack-welds used in the assembly of joints subject to primary stress from weight or pressure of tank contents and those used for assembling the tank shell to bottoms are to be removed ahead of the continuous welding. Tack-welds used in the assembly of joints subject to secondary stress, such as those in flat bottoms, roofs and circumferential seams of cylindrical tank shells need not be removed, provided they are sound and the cover beads are thoroughly fused into the tack-welds.

10.09 *Peening.*

(*a*) Peening of weld layers or passes may be used to prevent undue distortion. Surface layers shall not be peened.

(*b*) Peening shall be performed with light blows from a power hammer using a blunt nosed tool.

10.10 *Weld Contour.*

(*a*) In all welds, the surface passes shall merge smoothly into each other.

(*b*) Undercutting of base metal in plate adjoining the weld is a defect and shall be repaired, except as permitted in Section 11.08 (f) and (g).

(*c*) All craters shall be filled to the full cross-section of the weld.

10.11 *Weld Reinforcement.* On butt joints, no part of the finished face in the area of fusion shall lie below the surface of the base plate adjoining. The weld reinforcement shall be a minimum, preferably not more than $\frac{1}{16}$ in. above the surface.

10.12 *Chipping and Gas-Gouging of Welds.* The chipping at the root of welds and chipping of welds to remove defects may be performed with a round nosed tool, or by gas-gouging.

10.13 *Flat Tank Bottoms.* The bottom plates, after being laid out and tacked, shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding, and to provide, as nearly as possible, a plane surface.

10.14 *Tank Shell.*

(*a*) On vertical joints, weld metal, for any of the passes, may be applied with either upward or downward progress of the welding,

provided the manufacturer shall have qualified the direction he selects for each pass in his procedure qualification and operator tests.

(*b*) The shell plates shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding and which will avoid kinks at the vertical joints.

10.15 *Matching Plates.*

(*a*) *Lap Joints:* At all lap joints, the plates shall be held in close contact during the welding operation. The separation shall be not more than $\frac{1}{16}$ in. The size of the fillet shall be increased by the amount of the separation.

(*b*) *Butt Joints* (*primary stress*): In butt joints subject to primary stress from weight or pressure of tank contents, the adjoining plates shall be accurately aligned and retained in position during the welding operation, so that in the finished joint, the center lines of adjoining plate edges shall not have an offset from each other, at any point, in excess of 10 per cent of the plate thickness (Use the thickness of the thinner plate if of different thicknesses.) or $\frac{1}{16}$ in., whichever is larger.

(*c*) *Butt Joints* (*secondary stress*): In butt joints subject to secondary stress, the adjoining plates shall be accurately aligned and retained in position during the welding operation, so that in the finished joint, the thinner plate, (if one is thinner than the other), or either plate, (if both plates are of the same thickness), shall not project beyond its adjoining plate by more than 20 per cent of the plate thickness (Use the thickness of the thinner plate if of different thicknesses.) with a maximum of $\frac{1}{8}$ in.

10.16 *Grouting Column and Riser Bases.* After the tank has been completely erected and trued up, any space which may exist between column and riser bases and foundations shall be thoroughly wetted and filled with a 1:1 cement-sand grout forced under the base plates and filling the space completely. The materials and labor for the grouting are to be furnished by the contractor.

10.17 *Sand Cushion.* A sand cushion not less than 1 in. in thickness shall be provided under riveted flat tank bottoms on concrete slab foundations. The sand shall be furnished at the site by the purchaser and spread by the contractor. In the case of both riveted and welded tanks, after the tank has been completely erected, any space which may exist between the tank bottom and the concrete foundation, and extending for a distance of at least 18 in. inside the tank shell, shall be filled with a 1:1 cement-sand grout forced under the bottom so as to fill completely the space. The top of the founda-

tions shall be thoroughly saturated with water before the grout is poured. The materials and labor for grouting are to be furnished by the contractor.

10.18 *Cleaning Up.* Upon completion of the erection, the contractor shall remove or dispose of all rubbish and other unsightly material caused by his operations and shall leave the premises in as good a condition as he found them.

Section 11—Inspection

11.01 *Riveted or Welded Tanks.* The purchaser may, if he so specifies, require mill and/or shop inspection by a commercial inspection agency, the cost of which shall be paid by the purchaser. Copies of the mill test reports shall be furnished the purchaser if requested.

11.02 *Field Inspection.* It is required under these specifications that the field welding be inspected in the following manner by a qualified welding inspector designated by the purchaser. The contractor shall furnish equipment for trepanning or otherwise obtaining inspection specimens.

The quality of all accessible welds which carry stress from weight or pressure of tank contents shall be inspected by sectioning methods.

11.03 *Application.* The examination of the welded structure by sectioning methods is more satisfactory when applied to butt joints, which makes it highly desirable that the shell of the all-welded tank be constructed with butt joints throughout. While it is possible to cut sections from lap joints, it will require twice as many sections on the double-fillet-welded joints to obtain as many sections per unit length of joint as for butt joints.

11.04 *Sectional Specimens.*

(*a*) Sectional specimens are segments cut from the welded joints with a cylindrical cutting tool or spherical saw, which removes a portion of the plate bounding the welded joint and exposes thereon two (2) cross-sections of the weld. The segments must expose the full cross-section of the welded joint.

(*b*) Segments cut with a circular tool are called trepanned plugs; segments cut with a spherical saw are called spherical segments.

11.05 *Number and Location of Test Segments.*

(*a*) Sectional testing shall be confined to tank shell joints, particularly those subject to primary stress from weight or pressure of tank contents. It need not be applied to flat tank bottoms resting directly on grade or foundation, nor to the welds between

flat tank bottoms and the first ring of tank shell, nor to the welds connecting top curb angle to shell and to roof, nor to a roof not in contact with the stored liquid, nor to welds connecting manholes and other accessories.

(*b*) Joints subject to primary stress from weight or pressure of tank contents shall have one segment cut from the first 10 ft. of completed joint welded by each operator. Thereafter, cut one segment approximately every 100 ft. of joint. In cylindrical tank shells, cut at least one segment from the total footage of vertical seams in each shell ring. It is permissible to qualify two operators' work with one segment if they weld opposite sides of the same seam. When a segment of this type is rejected, it must be determined whether one or both operators were at fault, by subsequent tests of the individual operator's work.

(*c*) Joints subject to secondary stress shall have one segment cut from approximately every 200 ft. of joint, with at least one segment from each circumferential seam of cylindrical tank shells.

(*d*) It is to be recognized that the same welding operator may, or may not, weld both sides of the same joint. Insofar as possible, an equal number of segments shall be cut from the work of each operator welding on the tank, except that this requirement shall not apply where the length of joint welded by an operator is very much less than average.

(*e*) For lap joints, two segments shall be removed at each test point, one from each fillet weld. They shall not be taken on the same center line, but shall be offset approximately 3 in. parallel to the axis of the joint.

(*f*) Spherical segments shall be cut from the outside of the tank shell for butt joints and from the welded surface for lap joints.

(*g*) The location for cutting the test segments may be determined by the purchaser's inspector.

(*h*) Test segments shall be taken as the work progresses, as soon as practicable after all the joints accessible from one scaffold position have been welded.

11.06 *Size of Sectional Segments.*

(*a*) The width or diameter of the segment shall be not less than the width of the finished weld plus $\frac{1}{8}$ in. with a minimum of $\frac{1}{2}$ in.

(*b*) The segments shall be removed on the center of the weld in such a manner that at least $\frac{1}{16}$ in. of base metal will be removed with the segment on each of the two sides.

11.07 *Preparation of Sectional Segments.*

(*a*) Sectional segments may be etched for inspection by any of the following methods.

(1) Without requiring any finishing or other preparation, place in boiling 50 per cent solution of muriatic (hydrochloric) acid until there is a clear definition of the structure of the weld. This will require approximately 30 min.

(2) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solution of one part ammonium persulfate and nine parts of water by weight. The solution should be used at room temperature and should be applied by vigorously rubbing the surface to be etched with a piece of cotton kept saturated with the solution. The etching process should be continued until there is a clear definition of the structure of the weld.

(3) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solution of one part of powdered iodine (solid form), two parts of powdered potassium iodide, and ten parts of water, all by weight. The solution should be used at room temperature and should be brushed on the surface to be etched until there is a clear definition of the structure of the weld.

(*b*) To preserve the appearance of the etched segments they should, after etching, be washed in clear water, the excess water removed, then immersed in ethyl alcohol, and dried. The etched surfaces may then be preserved by coating with a thin, clear lacquer.

11.08 *Inspection of Sectional Segments.*

(*a*) The etched segments shall be examined to ascertain the extent of weld defects, such as gas pockets, slag inclusions, lack of fusion, undercutting and cracks.

(*b*) For all welds, the etched surfaces of the segments shall show complete fusion between the weld metal and the base metal within the depth of the weld required for the applicable joint. There shall be no cracks in any weld.

(*c*) Slag inclusion is permissible when it occurs between layers of the weld, is substantially parallel to the plate surface, and is equal to not more than one-half the width of the weld metal; and when it occurs across the thickness of the plate and is equal to not more than 10 per cent of the thickness of the thinner plate.

(*d*) Gas pockets are permissible that do not exceed $\frac{1}{16}$ in. in greatest dimension and when there are no more than six gas pockets of this maximum size per square inch of the weld metal and where the com-

bined areas of a greater number of pockets do not exceed 0.02 sq.in. per square inch (2 per cent) of weld metal.

(*e*) For butt and lap joints subject to primary stress from weight or pressure of tank contents, there shall be complete penetration and no undercutting.

(*f*) For butt joints subject to secondary stress, penetration is only required within the limits established by Section 8.04. A maximum undercut of $\frac{1}{32}$ in. at each edge of the weld may be permitted, provided the unwelded portion plus the undercut shall not reduce the thickness of the joint more than $\frac{1}{3}$ of the thickness of the thinner plate joined.

(*g*) For lap joints subject to secondary stress, an undercut $\frac{1}{32}$ in. deep, measured along either leg, and lack of penetration at the root of $\frac{1}{16}$ in., measured along either leg, or the throat, shall be the maximum permitted, provided the size of the weld is increased to compensate for the deficiency in root penetration.

(*h*) Where a defective segment is located, additional segments shall be cut from the same operator's work 2 ft. on each side of the defective segment, wherever the joint length will permit. If additional defective segments are found, then more segments shall be cut at intervals of 2 ft. on the same operator's work until the limit of the defective welding has been definitely established; or the contractor may proceed to replace all the welding done by that operator without cutting out additional segments.

(*i*) Defects in welds shall be removed by chipping or by gas-gouging from one or both sides of the joint, as required, and re-welding. Only sufficient cutting out of defective joints is to be required as is necessary to correct the defects. Replacement welds in joints shall be checked by repeating the original test procedure.

11.09 *Method of Closing Openings from Which Segments Have Been Removed.* Subject to the stated limitations, openings may be closed by any of the following methods:

(*a*) Openings cut with a spherical saw: For butt joints place a backing-up plate where necessary on the inside of the tank shell over the opening. For lap joints the base plate material opposite the weld will usually serve as a backing-up plate. The opening shall be completely filled with weld metal. Where fillet welds are cut, they shall be rebuilt.

(*b*) Trepanned plug openings for joints subject to secondary stress only: Insert a disc in the hole, which disc shall have a fairly close fit in the hole, and shall have a thickness at least $\frac{1}{8}$ in. less than the thickness of the thinner plate at the joint. The disc shall be

inserted in a mid-position between the surfaces of the thinner plate for butt joints and in a mid-position of the continuous plate for lap joints. Both sides of the disc shall be welded over completely, fusing the circular edges of the disc into the plate material and making the surfaces of the weld substantially flush with the plate surfaces. Rebuild fillet welds where cut.

(*c*) Trepanned plug openings for joints subject to primary or secondary stress and where the thickness of the thinner plate at the joint is not greater than $\frac{1}{3}$ of the diameter of the hole: Place a backing-up plate on the inside of the tank shell over the opening. Fill the hole completely with weld metal applied from the outside of the tank shell. Rebuild fillet welds where cut.

(*d*) Trepanned plug openings for joints subject to primary or secondary stress and where the thickness of the thinner plate at the joint is not less than $\frac{1}{3}$, nor greater than $\frac{2}{3}$, the diameter of the hole: Fill the hole completely with weld metal applied from both sides of the tank shell. Rebuild fillet welds where cut.

(*e*) Trepanned plug openings for butt-welded joints subject to primary or secondary stress and where the thickness of the thinner plate at the joint does not exceed $\frac{7}{8}$ in.: Chip a groove on one side of the plate each way along the seam from the hole. The groove at the opening shall have sufficient width to provide a taper to the bottom of the hole, and the length of the groove on each side of the opening is to have a slope of 1 to 3. Using a backing-up plate on the side opposite which the chipping is done, or a thin disc (not over $\frac{1}{8}$ in. thick) at the bottom of the hole, fill the groove and the hole with weld metal.

(*f*) Trepanned plug openings for butt-welded joints subject to primary or secondary stress and for plates of any thickness: Chip a groove on both sides of the plate each way along the seam from the hole. The groove at the opening shall have sufficient width to provide a taper to the middle of the plate, and the length of the groove on each side of the opening is to have a slope of 1 to 3. Place a thin disc (not over $\frac{1}{8}$ in. thick) in the hole at the middle of the plate and fill the grooves and the hole on both sides with weld metal.

11.10 *Record of Segments.*

(*a*) The segments after removal, shall be properly stamped or tagged for identification; and, after etching, kept in proper containers, with a record of their place of removal as well as of the welding operator who performed the welding. A record shall be made by the inspector, of all segments, with their identification marks on a developed shell-plate diagram.

(*b*) After the completion of the structure, the segments may be retained by the purchaser, if he so desires; otherwise they may be discarded.

11.11 *When Inspected.* It is required that the inspector be on the job before any welding is done, at which time the welding operators shall be qualified or their credentials accepted, after which welding may proceed. It is recommended that the inspector make the examination of the trepanned plugs immediately after the first vertical joints are welded to prevent a large amount of unacceptable welding being done which would later have to be removed. The inspector need, however, stay only until he is satisfied that acceptable work is being done, after which he may leave and then return when the welding to be inspected has been completed so that he may complete his inspection of the welds. The inspector shall, however, visit the job at least once during each month that the work is in progress.

11.12 *Who Pays for the Field Inspection.* The purchaser shall pay the cost of the field inspection. If the inspector is required to work a greater number of days, because of repeated tests due to faulty work or of additional trips to reinspect rejected work, the contractor shall pay the increased cost of such inspection over what it would have been if there had been no faulty or rejected work. The inspector shall report to the purchaser any instances where the contractor fails to repair any rejected work which controversy shall be settled between the purchaser and the contractor in a manner satisfactory to them. Upon completion of the work the inspector shall send a written acceptance of the workmanship to the purchaser and at the same time shall send a copy of such acceptance to the contractor.

Section 12—Testing

12.01 *Riveted Flat Bottoms.* Riveted flat tank bottoms shall be tested on horses before being lowered to the grade. Sufficient water shall be placed in the bottom to cover the bottom angle. Any leaks shall be corrected by calking or redriving rivets, if necessary.

12.02 *Welded Flat Bottoms.* After the bottom has been completely welded, including the attachment of the first course shell sheet, water to be supplied by the purchaser, may be pumped underneath the bottom, maintaining a head of at least 6 in. of liquid, by holding that depth around the edge of the bottom, inside a temporary dam; or the joints may be tested with a suitable material such as strong soap solution or linseed oil under air pressure or vacuum;

or the joints may be tested by the magnetic dust method. The bottom shall be made entirely tight to the satisfaction of the purchaser's inspector.

12.03 *General.* After the tank is completed, but before it is painted, it shall be filled with water furnished at the tank site by the purchaser at proper pressure to fill the tank to the maximum working water level. Any leaks which are disclosed in this test in either the shell, bottom, or roof (if the roof contains water) shall be repaired by either calking for riveted construction or by drilling, chipping or gas-gouging out any defective welds and then rewelding for welded construction. No repair work shall be done on any joint unless the water in the tank is at least 2 ft. below the point being repaired.

12.04 *Disposal of Test Water.* The purchaser shall provide means for disposing of test water up to the tank inlet or drain pipe.

Section 13—Field Painting

13.01 *General.* After completion of a satisfactory test, the tank shall be painted or coated in accordance with the purchaser's specifications. See Sections A-7 to A-11 inclusive for recommended paints and methods of protecting the tank against corrosion.

13.02 *Workmanship.* All painting shall be done in a workmanlike manner. The surfaces shall be cleaned of foreign material and if no shop paint has been applied, the steel shall be wire-brushed before applying the first coat of field paint. If the purchaser specifies that the mill scale be removed, and if pickling or sandblasting is not specified, it shall be understood that the rust and loose mill scale shall be removed by wire brushing only.

13.03 *Painting.* After cleaning the work shall be given the required number of coats of paint or other materials as specified by the purchaser and in the manner recommended by the manufacturer of such materials. Sufficient time shall be allowed for each coat to dry thoroughly before the following coat is applied.

13.04 *Aluminum Paint.* Where aluminum paint is specified for the exterior of the tank, the contractor shall apply the paint either by brush or spray, at his option, unless the manner of application is specified by the purchaser. The paint shall be applied as smoothly as possible.

Appendix

A-1 *General.* This appendix contains recommendations which are believed to represent good practice but they are not to be considered as requirements of the specifications.

A-2 *Information to Be Furnished by Purchaser for an Elevated Tank.*

1. Capacity.
2. Height to bottom capacity level or to overflow.
3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).
4. The range of head, if special range is required.
5. Type of joint construction, whether riveted or welded, if there is a preference.
6. Diameter and kind of riser pipe.
7. The desired time for completion.
8. Location of site.
9. Type of road available for access to the site and whether public or private.
10. Name of and distance to nearest town.
11. Name of and distance to nearest railroad siding.
12. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether direct or alternating current. If a.c., what cycle and phase.
13. Availability of compressed air, pressure, volume and charge, if any.
14. Safe bearing value of soil.
15. Corrosion allowance to be added: (a) to parts in contact with water, (b) to parts not in contact with water.
16. Safety cages required on ladders, if any.
17. Number and location of pipe connections, and kind and size of pipe to be accommodated.
18. Overflow, stub or to ground and size of pipe.
19. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?
20. Kinds of paint or protective coatings and number of coats: (a) inside surfaces, (b) outside surfaces.
21. Specifications for any additional accessories required.

A-3 *Information to Be Furnished by Purchaser for a Standpipe or Reservoir.*

1. If a standpipe, capacity and maximum height of water.

2. If a reservoir, capacity and diameter.

3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).

4. Type of joint construction, whether riveted or welded, if there is a preference.

5. The desired time for completion.

6. Location of site.

7. Type of road available for access to the site and whether public or private.

8. Type, thickness and kind of support of roof, if required.

9. Name of and distance to nearest town.

10. Name of and distance to nearest railroad siding.

11. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether direct or alternating current. If a.c., what cycle and phase.

12. Availability of compressed air, pressure, volume, and charge, if any.

13. Safe bearing value of soil.

14. Corrosion allowance to be added: (a) to parts in contact with water, (b) to parts not in contact with water.

15. Safety cages required on ladders, if any.

16. Number and location of pipe connections and kind and size of pipe to be accommodated.

17. Overflow, stub or to ground and size of pipe.

18. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?

19. Kinds of paint or protective coatings and number of coats: (a) inside surfaces, (b) outside surfaces except underside of bottom, (c) underside of bottom.

20. Specifications for any additional accessories required.

A-4 *Information to Be Furnished by Bidder for an Elevated Tank.*

(*a*) A drawing showing the dimensions of the tank and tower including the tank diameter, the height to lower and upper capacity levels, the sizes of principal members and the thickness of plates in all parts of the tank and tower. Also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

(*b*) The number, names and sizes of all accessories included.

A-5 *Information to Be Furnished by Bidder for a Standpipe or Reservoir.*

(*a*) A drawing showing the dimensions of the standpipe or reservoir

including the diameter, shell height, and the thickness of plates, the type and thickness of the roof, the thickness of the bottom interior and sketch plates, and the sizes or weights of structural members; also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

(*b*) The number, names and sizes of all accessories included.

A-6 *Drawings.* After award of a contract, the contractor shall prepare foundation plans and detail drawings, such drawings to be submitted to the purchaser for approval before proceeding with any fabrication. Unless prohibited by the purchaser, the steel may be ordered from the design drawings, and if any changes in capacity or governing dimensions are made by the purchaser which affect the steel ordered, any loss to the contractor shall be assumed by the purchaser. In the preparation of drawings for welded tanks, standard welding symbols as recommended by the American Welding Society shall be used.

A-7 *Cleaning and Shop Painting.* The purchaser shall specify the method of cleaning the steel and the type or make of paint or coating material to be used. The following alternative methods are believed to represent good practice:

(*a*) Plates and structural shapes may be sand, grit or shot blasted, or pickled, to remove the mill scale, after which they shall receive a shop coat of an inhibitive steel primer on all parts except contact surfaces and edges to be welded.

(*b*) Plates and structural shapes may be dehydrated with the oxy-acetylene torch, removing such mill scale as becomes loosened with one application of the torch followed by wire brushing, after which all parts shall be given one coat of inhibitive primer while the parts are still warm, except contact surfaces and edges to be welded.

(*c*) Plates and structural shapes may be fabricated and shipped to the erection site without paint, and then shall be erected and allowed to weather until the mill scale is loosened from both interior and exterior surfaces, after which the steel shall be dried, wire brushed and painted with one coat of an inhibitive steel primer on all surfaces. *Note:* This method may be objectionable because of the possibility of mill scale being carried into the distribution system.

(*d*) If no special cleaning is desired, the steel may be painted with an inhibitive primer directly over the mill rolled surfaces, after removing such rust, loose scale and other foreign material as may be

removed by wire brushing. The contact surfaces or welding edges should not be painted.

A-8 *Field Painting.* After the tank is completely erected, and after it has been tested, interior and exterior surfaces should be cleaned of dirt, rust or foreign material, the welding edges or rivet heads wire brushed, and then any abraded spots and all accessible surfaces which were not painted in the shop shall then be spot coated with the inhibitive primer used in the shop, after which the interior and exterior surfaces shall be given the number of coats of paints of the makes or types, and colors specified by the purchaser.

A-9 *Kind of Paint.* It is recognized that various types and kinds of paint have in great measure demonstrated their suitability for water works use and that no one type or kind is universally applicable. The following are indicative of what is believed to be best practice at present.

(*a*) *Interior Paint:* All interior surfaces of the tank shall be given one coat of interior first coat paint, either in the shop or in the field.

After erection the first coat, if applied in the shop, shall be retouched and all seams and other surfaces not painted in the shop, shall be painted with the same paint.

After the first inside paint coat has thoroughly dried, all inside surfaces shall be given a coat of inside second coat paint in accordance with the formula in Section A-10.

(*b*) *Outside Surfaces:* All outside surfaces, including all structural members with the exception of the underneath surface of flat bottoms, shall be given one coat of outside first coat paint in the shop or in the field.

After erection, if the first coat was applied in the shop, it shall be retouched with the same paint covering any abraded spots or surfaces which were not painted in the shop, after which all outside surfaces shall receive a second coat of either outside black paint or outside aluminum paint.

(*c*) *Underside of Flat Tank Bottoms:* The underside of flat tank bottoms shall be painted in the field. If the bottom is riveted, it shall be painted after it is tested and while it is on horses. If welded, the bottom plates may be painted and, after drying, placed in position on the grade before being welded. The underneath surfaces of bottoms shall be painted with black asphalt paint.

A-10 *Types and Kinds of Paint.* The following paints are suggested as suitable for painting tank structures.

All ingredients of the following paints shall be in accordance with

applicable current specifications of the American Society for Testing Materials.

(*a*) *Paint Number 1—Inside First Coat:*

Paste Red Lead	100 lb.
Boiled Linseed Oil	1.625 gal.
Fine Litharge	10 lb.

Beat up the litharge in one quart of boiled oil and add to paint. Makes about 4.25 gal. of paint.

Paint should be applied without thinning whenever temperatures are high enough to permit thorough, smooth brushing out (about 70° F.). When paint is too thick to brush out smoothly, turpentine may be added, using the minimum amount necessary to secure proper consistency, but in no case to exceed 3 pints of turpentine to 100 lb. of paste red lead. (The above is substantially in compliance with Federal Specifications of the Bureau of Standards TTP-86, adopted September 9, 1939.)

(*b*) *Paint Number 2—Inside Second Coat:*

Same as first with addition of 0.75 lb. of paste lampblack to each batch.

(*c*) *Paint Number 3—Outside First Coat:*

Paste Red Lead	100 lb.
Raw Linseed Oil	2.125 gal.
Drier	1 qt.
Turpentine	1 qt.

Makes about 4.87 gal. of paint.

Note: The above red lead paint formulas are based on paste red lead made by grinding 100 lb. of dry red lead with 8 lb. of linseed oil.

(*d*) *Paint Number 4—Outside Second Coat—Aluminum Finish:*

Pigment—2 lb. Aluminum Paste
Vehicle—1 gal. long oil varnish

The aluminum paste shall comply with the latest revision of A.S.T.M. Specifications D 474 (type A).

Long oil varnish shall comply with the following specifications:

The vehicle shall consist of a long oil varnish, made from ester gum, cumaroneindene, Amberol B1 or F7 or other suitable resins, together with suitable drying oils, and shall fulfill the following requirements:

(1) The varnish shall be clear and transparent.

(2) The viscosity shall be between 0.65 and 1.25 poise at 25°C. (77°F.), corresponding to Tubes B to E of the Gardner-Holdt Air Bubble Viscometer.

(3) The acid number of the vehicle shall be less than 15, based on the non-volatile content of the varnish.

(4) It shall contain not less than 50 per cent by weight of non-volatile oils and gums.

(5) It shall pass a 60 per cent Kauri Reduction Test as described in Federal Specification TT-V-81, paragraph F-2g.

(6) When thoroughly mixed with the aluminum paste specified in the proportion of 2 lb. per gal. of vehicle, the paint shall have good leafing quality, show satisfactory brushing and leveling properties, and shall not break or sag when applied to a vertical, smooth, steel surface.

(7) The paint shall set to touch in not less than 1 hr. nor more than 6 hr. and dry hard and tough in not more than 24 hr. at a temperature of 20°C. (68°F.) to 30°C. (86°F.).

(e) Paint Number 5—Outside Second Coat—Black Color:

The paint furnished shall comply with the United States Department of Commerce Circular of the Bureau of Standards, No. 94, U. S. Government Master Specification 14b for ready-mixed paint.

(f) Paint Number 6—Asphalt Varnish for Underneath Surface of Flat Bottoms:

Paint furnished shall comply with U. S. Government Specification for Asphalt Varnish, Federal Specification Board Standard Specification 19, revised January 2, 1923.

A-11 *Electric (Cathodic) Protection of Tank Interiors.* The electrolytic method of protecting water tank interiors has proved to be entirely satisfactory when properly installed and maintained. It is, therefore, recommended for the protection of interior tank surfaces except in cold climates where ice may dislodge the electrodes.

A-12 *Foundations—General.* The foundations for elevated tank structures are of considerable importance, because any unequal settlement changes considerably distribution of stresses in the structure and may cause leakage or buckling of the plates. The tops shall be located accurately at the proper elevation. The following is recommended practice with regard to foundations.

A-13 *By Whom Designed.* The contractor shall furnish foundation plans based on an assumed soil pressure of 4,000 lb. per sq.ft. for usual conditions. If purchaser's soil bearing value is different than 4,000 lb. per sq.ft., special foundations shall be designed jointly by the purchaser and contractor or their representatives, the purchaser to bear the cost of any required field tests. Foundations shall be installed by the purchaser who shall furnish all materials except anchor bolts. The earth around the foundations shall be regraded sufficiently to permit efficient work during erection.

A-14 *Soil Bearing Value.* Unless the purchaser has knowledge of the soil at the tank site, he shall conduct suitable tests to determine the character and safe bearing value of the soil and its condition as regards homogeneity, freedom from old excavation or fill or faults of any kinds.

The following are average soil bearing values.

1. Quick sand and wet alluvial soils, ½ ton. per sq.ft.
2. Soft wet clay or sand, 1 ton per sq.ft.
3. Ordinary clay, dry sand mixed with clay, moderately dry sand or firm dry loam, 2 tons per sq.ft.
4. Compact coarse sand or hard clay or gravel, 3 tons per sq.ft.
5. Hard pan or shale in horizontal layers and dry, 5 tons per sq.ft.
6. Hard rock, 20 tons per sq.ft.

A-15 *Riser Foundations.* Foundations for the riser pipe shall be provided with a tunnel of adequate size to accommodate the base ells for the piping specified by the purchaser. The opening shall be covered with a sufficient thickness of concrete either properly reinforced to support the load on the riser pipe bottom, or steel beams may be provided for this purpose. The foundation beneath the tunnel shall be adequately reinforced. The contractor shall furnish plans for the riser foundation.

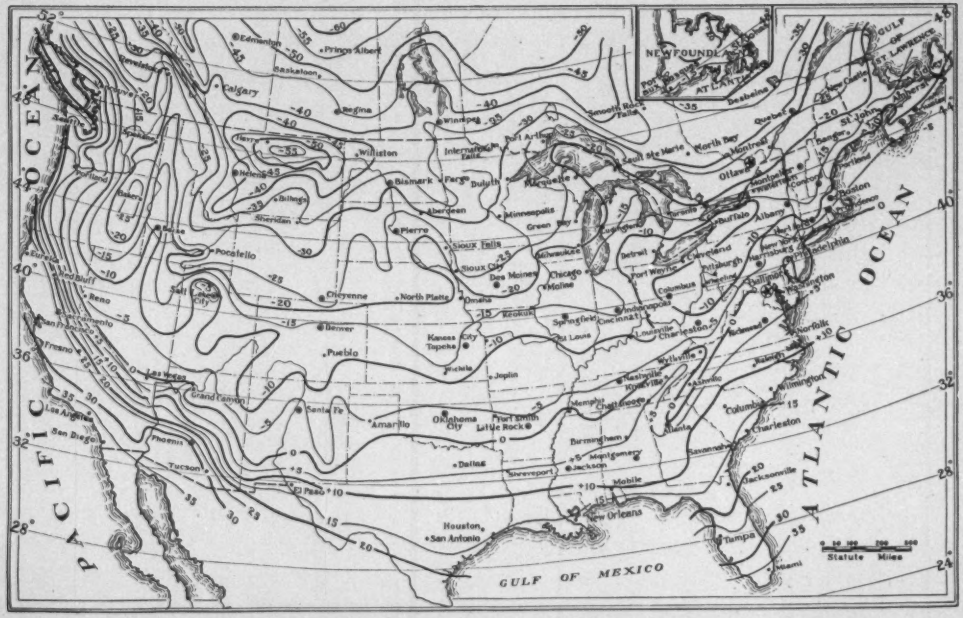
A-16 *Column Foundations.* Column foundations may be of any suitable shape and may be either plain or reinforced. The weight of the pier shall be sufficient to resist the maximum net uplift occurring with the tank empty and wind load as specified in Section 3.02 blowing in the direction causing the greatest net uplift on any pier. The weight of earth directly above the base of the pier may be included to resist uplift.

A-17 *Concrete Design and Materials.* The design of the concrete foundations, the specifications for the cement and aggregate and the mixing and placing of the aggregate shall be in accordance with the joint code of Building Regulations for Reinforced Concrete, Report of Committee E1 of the American Concrete Institute and Concrete Reinforcing Steel Institute Committee on Engineering Practice.

A-18 *Detail Design of Foundations.*

(*a*) *Batter:* For battered columns without bottom struts the axis of column foundations shall have the same batter as the column. For battered columns with bottom struts attached to columns or if piers are tied together and for vertical columns the axis of the foundations shall be vertical.

(*b*) *Height Above Ground:* The tops of the concrete foundations shall be at least 6 in. above the ground.



Isothermal Lines– Lowest One-Day Mean Temperatures (Compiled from United States Weather Bureau Records up to 1925); reproduced by permission of the Associated Factory Mutual Fire Insurance Companies

(c) *Minimum Depth:* The minimum depth of foundations shall be determined from the minimum average one-day mean temperature chart, as follows:

For minimum temperatures over 32°F.—3 ft. 0 in.

For minimum temperatures under 32° to and including +10°F.—3 ft. 6 in.

For minimum temperatures under +10° to and including −10°F.—4 ft.

For minimum temperatures under −10° to and including −20°F.—4 ft. 6 in.

For minimum temperatures under −20° to and including −30°F.—5 ft. 0 in.

For minimum temperatures under −30° to and including −40°F.—5 ft. 6 in.

For minimum temperatures under −40°—6 ft. 0 in.

The above minimum depths refer to the depth of the base below the ground line. They should be increased in localities where soil or other factors are favorable for deep frost penetration.

A-19 *Size of Top.* The tops of foundations shall project at least 3 in. beyond the column or riser base plates. The top corners shall either be neatly rounded or finished with suitable bevel.

A-20 *Pouring.* The riser and column piers shall each be poured monolithically, without any interruption of sufficient duration to permit the concrete partially to set. If it is necessary to pour piers in more than one pour, a sufficient number of dowels shall be used to transmit all specified loads and horizontal wind load shears.

A-21 *Finish.* The top portions of piers to a level 6 in. below the proposed ground level shall be finished smooth. Any small holes may be troweled over with mortar as soon as possible after the forms are removed.

A-22 *Design of Foundations Without Reinforcement.* Unreinforced piers shall have a vertical portion at the base at least 6 in. in height and shall be designed according to the following allowable unit stresses based on the 28-day compressive strength of the concrete used.

Maximum tension in bending, including wind load, 1.5 per cent of 28-day compressive strength.

Maximum shear, including wind load, 2 per cent of 28-day compressive strength.

Maximum bearing, 20 per cent of 28-day compressive strength for dead and live loads or 25 per cent for dead and live loads combined with wind load.

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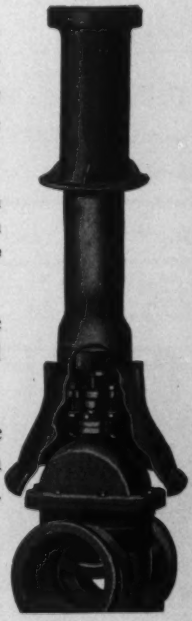

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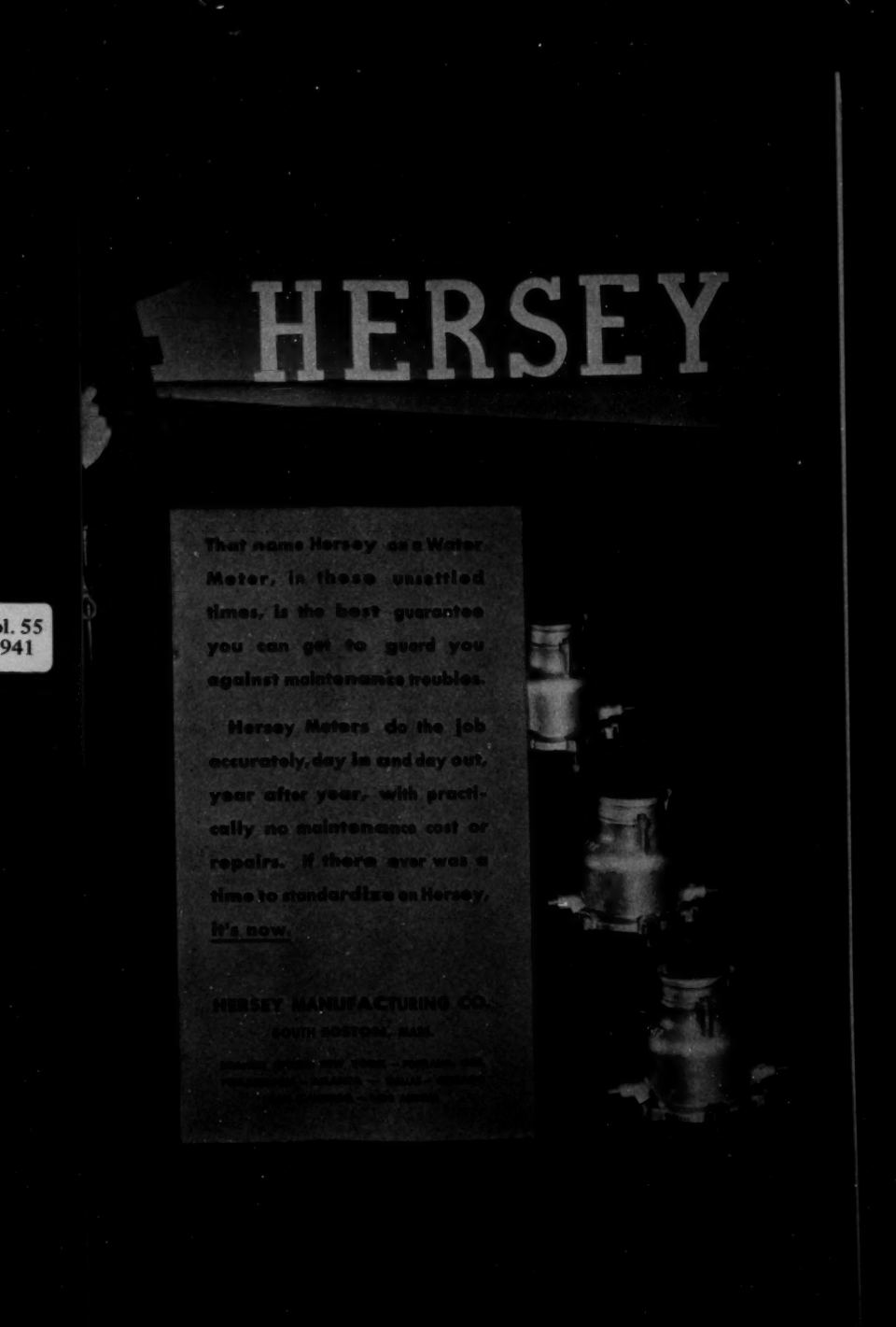
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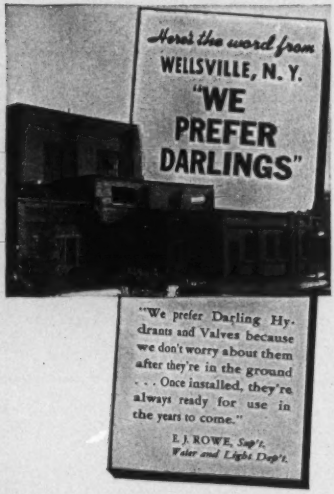
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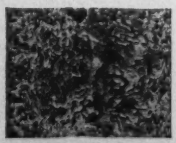
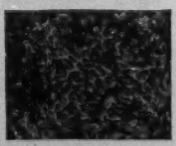


Photomicrograph (mag. 100x) showing the structure of a typical sample of cast iron as ordinarily produced. Note the entrained inclusions tending to break down the strength of the metal and produce leaks.



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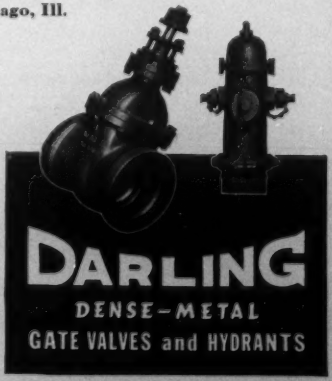

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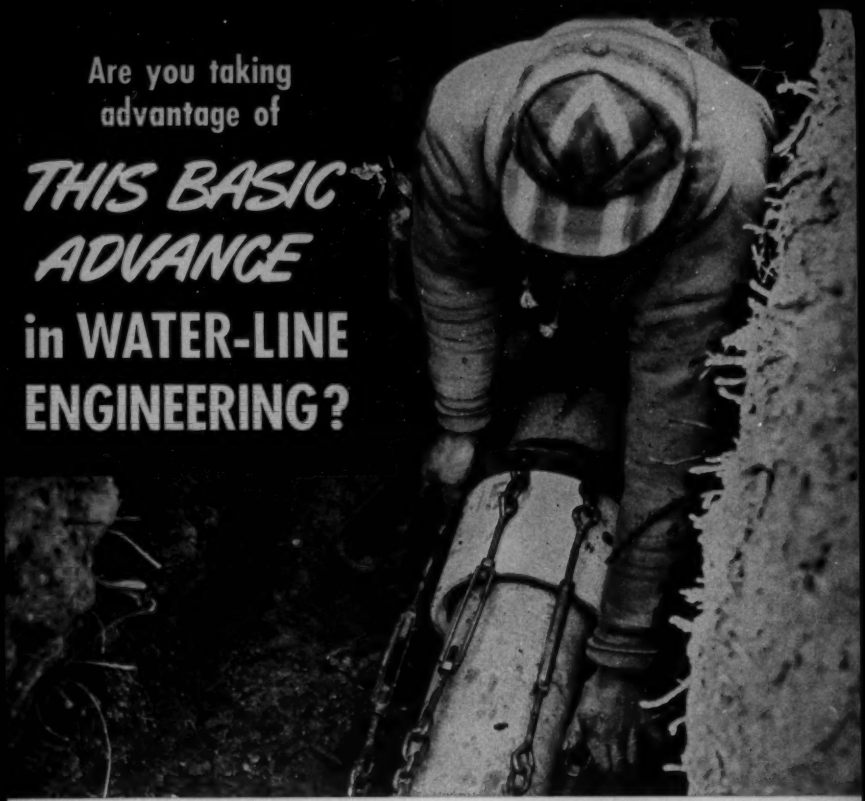

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Large standpipes and inlet valves, carefully shaped entrance elbow, bell-shaped nozzles, and absence of obstructions through the hydrant combine to minimize friction loss and to assure practically full main pressure at the nozzles. In addition, the simple straight-line mechanism assures easy operation.

Extra Safety . . . .

When struck by an impact which *no* hydrant could withstand, the Safety Breakable Section of the Kennedy SAFETOP parts cleanly, and no flooding can occur. Occupants of the colliding vehicle are protected from likelihood of severe personal injury, and the neighborhood is protected from damage by water or lengthy delay in returning the hydrant to service.

Send for Bulletins

The Kennedy Valve Mfg. Co., Elmira, N. Y.

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SAFETOP FIRE HYDRANT

REG. U.S. PAT. OFF.

EDDY

Valves and Hydrants

Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

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Used by leading WATER WORKS for over 50 years. If proper weight is used, combined with good workmanship, your FINAL COST is assured, as REPAIRS are unnecessary. LEAD PIPE IS sufficiently ductile to conform to any sagging condition. There is no RUSTING of pipe or joints; no DISCOLORATION of water.

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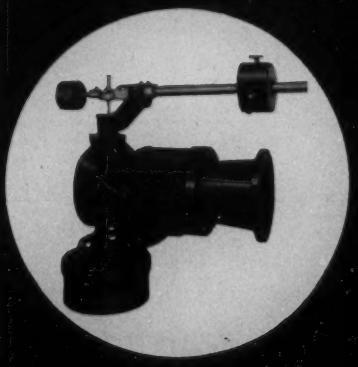

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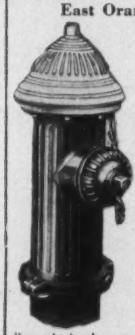

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Machines for inserting valves under pressure, and for making large right angle connections to mains under pressure, and for inserting house service connections under pressure.
Also makers of—
Pipe Cutting Machines, each size being adjustable for use on three different sizes of pipe.
High-grade water works supplies, such as Hydrants, Valves, Meters, Corporation Cocks, etc.
We also make a new type of hydrant which has a breakable joint at the ground line which when struck with an impediment will break at a specified point and only a coupling has to be used to repair the hydrant, which will be back in service in twenty (20) minutes.
"HYDRANT WITH BREAKABLE COUPLING"

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FOR RISER SETTINGS . . FOR ANGLE SETTINGS . . FOR LINE SETTING
MAKE EASY METER CHANGES

Made in sizes for meters up to 1".

Ford Yokes connect inlet and outlet service pipes permanently and make easy, trouble-free meter changes. May include a.. inverted ground-key angle valve at the meter inlet. Made for all types of piping connections. Hundreds of thousands in service. Further information for the asking.

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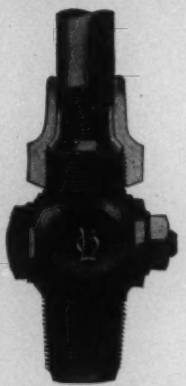

Fig. 0108ER
Hays Radius Seal
Copper Stops

This heavy duty New England line of Hays Water Works Brass Goods is available for copper, iron, or lead pipe services in popular styles and sizes — a few are shown. It is easy to understand the rise of Hays in the industry when you realize that this same spirit of cooperation is extended to all sections of the U.S.A.

Everywhere the name HAYS on brass is respected, not only for the quality of the product, but for the quality of the relationship that exists between Hays and its customers. How can Hays serve you today?

Hays
Lead
Flange
Stops

Fig. 0115A

Hays - New England
Curb Stops

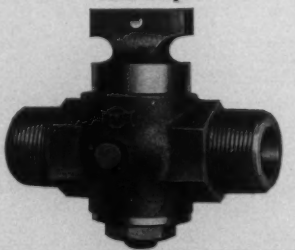

Fig. 079R

Write for Hays Catalog No. 5

Hays
New England
Pattern
Angle
Type
Stops

Fig. 0175K

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Sewage Pumps
that do not clog

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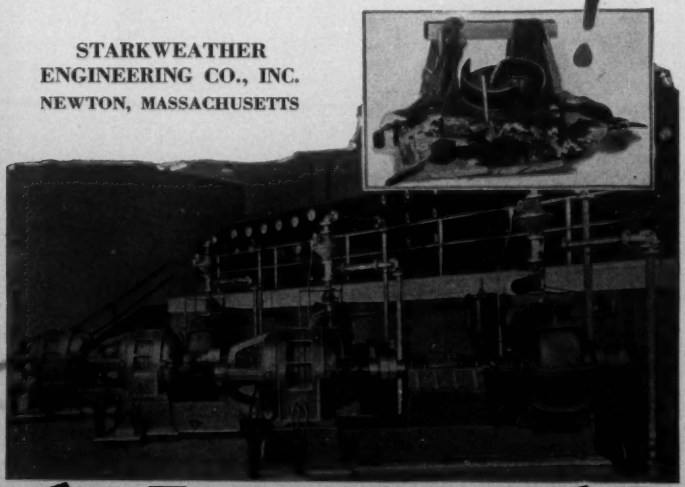
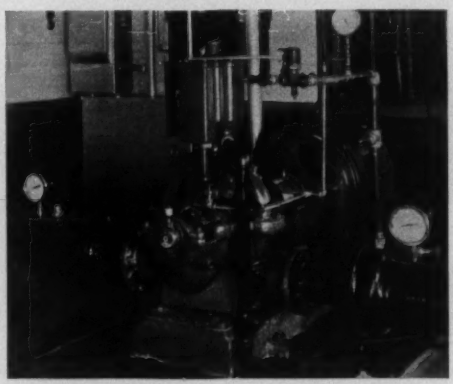
NEWTON, MASSACHUSETTS



MORRIS
CENTRIFUGAL PUMPS

DE LAVAL

Automatically Primed Centrifugal Water Works Pump



Town of Brookline — West Roxbury Station

The above unit is fitted with the patented De Laval Class 1 Submerged Suction Priming System. It supplies water for filter sand washing. The ¾" corporation cock, shown in the suction piping, can be opened fully, with the pump in operation, causing complete cessation of delivery and the pump will reprime itself and again deliver water within one minute after closing the corporation cock. The entire system is completely automatic and is supplied integrally with the pump. It incorporates safety devices within the priming chamber. May we explain our system to you in greater detail?

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TRENTON, NEW JERSEY

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FOR WATER SUPPLIES

HERE'S THE NEWEST CONTRIBUTION of W&T engineering to public health defense... a trailer-type mobile chlorinating unit, designed to provide positive protection of water supplies under emergency conditions, or to meet any need for closely controlled chlorination "on location" without delay.

Using the dependable W&T vacuum principle, the unit provides for solution feed of chlorine over a wide range of application rates up to 100 lb. of chlorine per day. Self-powered by a gasoline motor, it will draw injector water from an open source or pipe line, and apply the chlorine in the main against pressures as high as 100 lb. per sq. in. Two 150 lb. chlorine cylinders are cradled in the trailer, connected to assure continuity of supply. Hoses, cocks, tools and other accessories for making emergency main connections are provided.

Data and experience gained by W&T technical experts in England during the past year, backed by W&T's continuous experience with emergency chlorination equipment extending from before the last World War, are reflected in the design and construction of the unit.

Both trailer frame and chlorinator are designed to stand up under the strenuous conditions of transport and service which exist during emergencies when faithful performance is most essential. Construction is exceptionally rugged to provide ample strength for rigorous duty.

SA 120A

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W&T *"Technical Publication 228"* describes the new Emergency Chlorination Trailer in detail.

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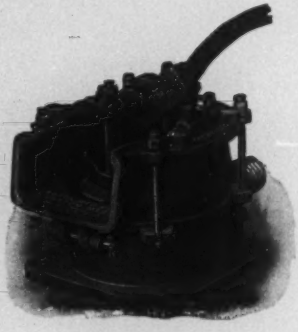
EDSON
PUMPS and ACCESSORIES



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NO LOSS IN CAPACITY
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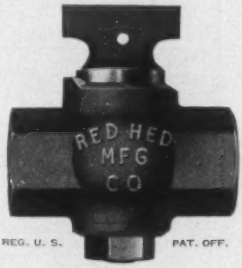

Fig. 222

The reputation RED HED MFG. CO. has attained for making high grade brass goods is the result of the selection of proper materials, the employment of experienced craftsmen and strict adherance to every detail in manufacture.

You can benefit from the use of RED HED Brass Goods.

RED HED MFG. CO.

Manufacturers of

Red Hed Brass Goods for Water Works

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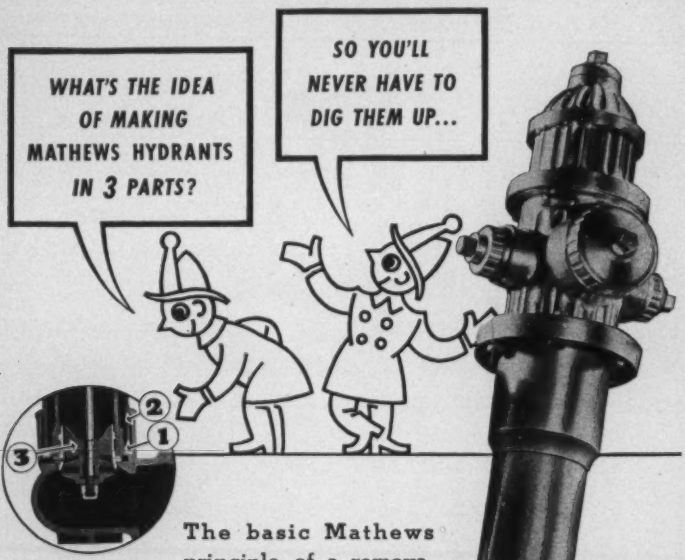

The basic Mathews principle of a removable barrel containing all operating parts is now 75 years old. It cannot be improved upon, for the elbow and protection case are permanently in the ground, yet the hydrant can be repaired, replaced, overhauled, modernized, raised, or lowered, from above ground, with *no* digging. Note that the barrel screws tight into the elbow at (1) while a loose frost casing (2) allows it to be removed complete with main and drain valve and their seats (3).

Write for detailed description, demonstration, or prices.

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Made by R. D. WOOD COMPANY

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A. Will Withstand Severe Strains.

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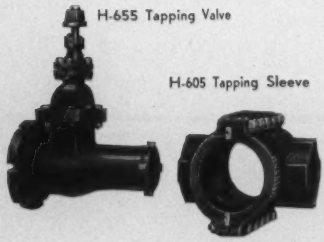

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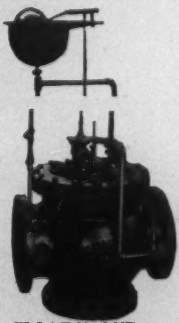

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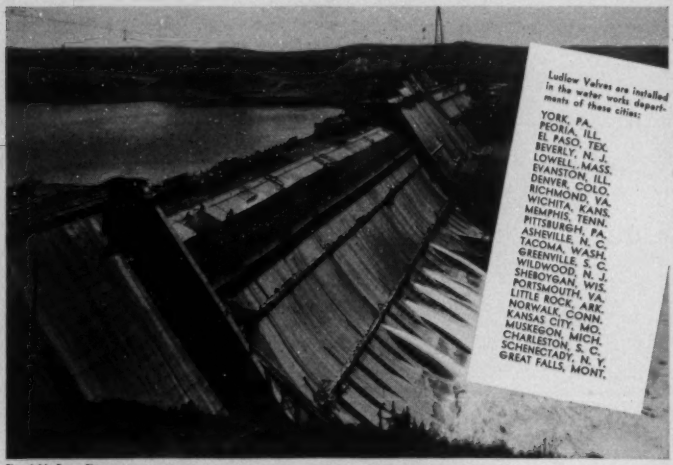

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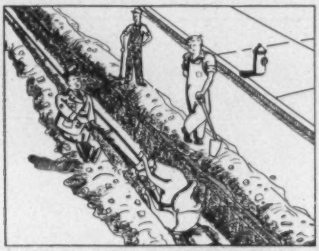

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